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The Arc-Spectra of the Elements, Lanthanum, Vanadium, Zirconium.

DISSERTATION

Submitted to the Board of University Studies

of

Johns Hopkins University

for the

Degree of Doctor of Philosophy.

by

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THE ARC-SPECTRA OF THE ELEMENTS.

INTRODUCTION.

The arc-spectra of many of the elements have been carefully investigated within the last few years by modern methods, and tables of wave-lengths of these lines have been published.

However, a number of elements still remain, whose arc-spectra are but little known, and it was with a view to extend our knowledge of some of these that the present work was undertaken.

Arc-spectra offer an advantage in regard to uniformity, sharpness of lines and the short time of exposure required for making grating photographs in comparison with those obtained from the spark-spectra.

Again, the lines are more comparable with those in the solar spectrum. The intensity of these as represented by a ratio to those in the solar spectrum are very nearly constant, if they occur at all. It simplifies the work very materially in the determination of the solar lines. The arc spectrum as obtained by the vaporization of the elements or their compounds between carbon poles present some diffi-

culties. Perhaps the most serious is the presence of the band spectrum of carbon or its compounds. These bands are frequently so dense as to prevent the identification of faint lines.

All grating spectra are comparable: for in the use of the grating spectra are obtained in which the wave-length of a line is directly proportional to the sine of its regular deviation.

The concave grating when used with the Rowland Mounting has the advantage that the wave-lengths of lines are directly proportional to their linear displacement upon the photographic plate and may be measured directly by means of the dividing engine whose pitch has been determined in terms of the unit of wave-length. Where a high degree of accuracy is essential, the great dispersion of a grating is an additional advantage. By its use we are able to photograph a larger portion of the spectrum on one plate than is possible by any other method.

This is a portion of an investigation which has been undertaken on the arc-spectrum of certain metals which have hitherto not been carefully studied by modern methods. The work is confined to the visible and ultra violet part of the spectrum.

DESCRIPTION OF PLATES.

The spectra photographs employed for the measurements were taken by Professor Rowland. The grating used was a six inch concave grating of 21 1/2 feet focal length with the usual mounting and is described by Professor Ames in the Johns Hopkins University Circular of May, 1889. The plates were taken chiefly in the first and second order, and extend from the extreme limit of the ultra-violet in air as far as 5000 or in many cases as far as the E lines.

The plates are 19 inches in length, and each contains somewhat more than 400 Angstrom units in the second order spectra. The second order plates are uniformly accompanied by the solar spectrum for comparison according to the method of Rowland, i.e., half of the exposure of the solar spectrum is made before, and half after the exposure for the arc-spectrum.

PHOTOGRAPHIC METHODS.

To produce the arc-spectra cored carbons were used, the openings being filled with the desired element or one of its compounds. With a moderately strong arc the requisite

exposure was from about three to ten minutes for the second order spectrum.

The plates used were flowed with emulsion by Professor Rowland who used slow emulsion to give a fine grain to the plates. For use in the green and as far as 6000, erythrosin was introduced with the emulsion, and the plates prepared in this way proved highly orthochromatic. Absorbing screens of glass or a solution of aesculin were used in photographing the region of longer wave-length in order to remove as far as possible the ultra-violet lines of overlapping spectra. Pyro and Hydro-chinan were used in developing and in most cases the latter gave the better results.

IDENTIFICATION OF LINES.

With a little experience, the investigator will be able to select from among the lines upon almost any plate, a few of those due to the element introduced into the arc. These are frequently to be recognized by their intensity and physical similarity, or by their reversal. The only reliable method, however, is what may be termed a process of exclusion. It is best to begin by accounting for all the impurity lines from the carbon poles. This may be done to some extent by comparison with the spectrum of some other element. This

will contain many of the same impurity lines, while lines due to the elements under investigation will be absent, if the comparison spectrum be suitably chosen. The plates are all very nearly of the same scale, so that any two, representing the same spectral region may be directly compared by superposing them with the film sides in contact. Small clamps of wood are then applied to hold them in this position, after which they may be carefully examined from end to end with a magnifying glass, and coincidences noted. The adjustment of the plates for comparison should be made with the greatest possible care or erroneous coincidences are sure to be recorded. In making comparisons it is of the utmost importance to observe carefully the relative intensities of each pair of coinciding lines, or, more generally, if the plates have been exposed unequally, the relative intensities that would have been observed under similar conditons of exposure. If the intensities are the same, the line is probably due to a common impurity. If not, the difference of intensity is a rough indication of the relative amount of the corresponding material present in the two spectra, and this gives an immediate clue to the origin of the line.

MEASUREMENT OF WAVE-LENGTHS.

The basis of all measurements is Table of Standard Wave-Lengths.[1]

Having carefully determined as far as possible to what element each line is due, and recording the same, the wave-lengths of the lines were measured. The dividing-engine used for this purpose was designed by Professor Rowland. The screw was made according to his method and is described in detail in the Encyclopedia Britanica, Article "Screw". Its pitch was made very nearly equal to one Angstrom unit upon spectrum plates of the second order, made with a grating of 21 1/2 feet focal length and ruled with 20,000 lines to the inch. Thus wave-lengths may be measured directly with only a small correction, depending upon slight variations in the scale of the plate, or upon its want of parallelism with the direction of the ways upon which the carriage of the engine moves. Measurements in the first order spectrum are evidently to be multiplied by two.

A correction for each line is obtained by measuring numerous solar and metallic standard lines in addition to those of the element studied. The difference in wave-lengths

[1] Rowland. A New Table of Standard Wave-lengths. Astron. A. P. 12, 1893.

taken from the table and the corresponding lines measured give when plotted a correction curve for each plate. The character of line and its position on the plate is considered in assigning weights preparatory to drawing the correction curves.

The wave-length of each line is the mean of at least two readings, direct and reversed. By "Direct"reading is meant that which is obtained when the plate is being moved so that the successive lines seen through the microscope are of ~~de-~~ increasing wave-length.

Whenever the same line has been measured upon more than one plate, the weighted mean of all the readings is taken as the final value for the wave-length.

A correction has been made for the Earth's motion for latitude 39° - 18' on the study of vanadium for wave-lengths 4182.733 to 5786.413 inclusive. No correction has been made for the dispersion of the air in the measurements here given, nor for the temperature and pressure of the atmosphere.

The plates were all made at a barometric pressure of approximately 76 cm., and at a temperature not differing much from 20° C.

DESCRIPTION OF THE TABLES.

In the following tables the intensities are given on a scale from 1 m (very faint and nebulous on the plate) to 20 (strongest line). The column headed wave-lengths (uncorrected) are readings taken from the engine. Corrections marked 1 and 2 are obtained respectively from the correction curve and from values calculated for the Earth's motion for 39° 18'. The symbol * after a corrected wave-length means the average of several measurements on different plates.

Hasselberg's readings are taken from his article in the Astrophysical Journal, "Note on the Chemical Composition of the Mineral Rutile". Vol. VI, p. 22, June, 1897.

The wave-lengths of vanadium from 4182.733 to 5786.413, inclusive, were measured from plates recently taken, and their time of exposure was duly recorded. This permitted the correction for the Earth's motion. A similar correction could not be applied to other wave-lengths, as there was no record of the date of their exposure. In measuring the lines in the arc-spectra numerous standard lines were also measured for the purpose of drawing a correction curve. The plate marked "Solar lines for Standard" have in the first

column micrometer readings; the second column headed "Standard" are taken from the table of Standard Wave Lengths; the third column, marked "Difference" is the difference between the standard and the micrometer reading, with the proper sign prefixed. The remaining columns are values calculated as due to the Earth's motion. The symbols +, ±, *, 11, (except where specially noted) represent the relative weights assigned to standards in plotting the correction curves, and are in ascending scale of magnitude.

In conclusion I wish to thank Professor Rowland and Dr. Ames for their suggestions and encouragement throughout the entire course of work.

SOLAR LINES FOR STANDARDS.

PLATE 32

Micrometer readings	Standard	Difference	Micrometer readings	Standard	Difference
3079.715	.724	—.009	3232.414	.404	+.010
3080.850	.863‡	—.013	3246.133	.124‡	+.009
3086.879	.891‡	—.012	3247.694	.680†	+.014
3094.723	.739	—.016	3260.389	.384*	+.005
3094.999	95.003	—.004	3267.846	.839	+.007
3115.141	.160	—.019	3274.093	.092†	+.001
3121.265	.275‡	—.010	3287.792	.791‡	+.001
3137.443	.441	+.002	3295.955	.957	—.002
3140.868	.869	—.001	3302.510	.501‡	+.009
3167.299	.290*	+.009	3303.648	.648‡	.000
3172.179	.175‡	+.004	3308.928	.928*	.000
3176.117	.104*	+.013	3318.162	.163*	—.001
3188.140	.164‡	—.024	3331.748	.741*	+.007
3200.030	.032‡	—.002	3348.015	.011*	+.004
3218.400	.390	+.010	3351.888	.877	+.011
3224.378	.368	+.010	3356.230	.222	+.008
3231.450	.421†	+.029	3377.669	.667‡	+.002

PLATE 36.

Micrometer readings	Standard	Difference	Micrometer readings	Standard	Difference
3405.200	.272‡	—.072	3558.670	.670†	.000
3406.510	.581	—.071	3564.686	.680‡	+.006
3406.886	.955	—.069	3570.236	.225†	+.011
3425.672	.721	—.049	3581.337	.344†	—.007
3440.720	.759†	—.039	3583.490	.483	+.007
3441.095	.135†	—.040	3597.198	.192	+.006
3455.338	.384	—.046	3600.875	.880‡	—.005
3464.571	.609	—.038	3612.234	.217	+.017
3486.010	.036‡	—.036	3618.946	.924†	+.022
3491.446	.464	—.018	3622.170	.147‡	+.023
3497.990	.991‡	—.001	3623.345	.332	+.013
3500.698	.721	—.023	3631.632	.619†	+.013
3510.987	.987	.000	3640.555	.536‡	+.019
3518.471	.487	—.016	3652.614	.692	+.022
3521.392	.404†	—.012	3658.719	.688	+.031
3540.257	.266‡	—.009	3667.424	.397	+.027
3545.339	.333*	+.006	3680.077	.064†	+.013
3550.000	.006	—.006	3683.228	.202‡	+.026

PLATE 36—*continued.*

Micrometer readings	Standard	Difference	Micrometer readings	Standard	Difference
3687.630	.607†	+.023	3770.156	.130*	+.026
3695.220	.194‡	+.026	3780.870	.846‖	+.024
3707.223	.186‡	+.037	3781.347	.330‖	+.017
3709.385	.397†	—.012	3783.700	.674‡	+.026
3716.595	.585‡	+.010	3794.039	.014‖	+.025
3720.105	.086†	+.019	3795.176	.150†	+.026
3732.566	.542‡	+.024	3804.198	.153‖	+.045
3737.308	.282†	+.026	3805.521	.487*	+.024
3743.529	.502†	+.027	3820.590	.567†	+.023
3745.718	.701‡	+.017	3821.348	.318‡	+.030
3756.240	.211	+.029	3823.679	.651‡	+.028
3763.968	.942†	+.026	3826.039	.024†	+.015

PLATE 40.

Micrometer readings	Standard	Difference	Micrometer readings	Standard	Difference
3804.105	.153	—.048	3961.682	.676†	+.006
3805.441	.487*	—.046	3971.482	.478‖	+.004
3815.940	.985†	—.045	3977.898	.891‖	+.007
3821.278	.318†	—.040	3981.927	.914‖	+.013
3823.617	.651‡	—.034	3984.086	.078†	+.008
3826.007	.024†	—.017	3987.243	.216†	+.017
3832.418	.446†	—.028	4003.927	.916*	+.011
3836.192	.226‖	—.034	4016.584	.578‖	+.006
3856.509	.517‡	—.008	4029.805	.796‖	+.009
3860.032	.048†	—.016	4030.918	.914†	+.004
3864.425	.441	—.016	4033.221	.225†	—.004
3871.519	.528*	—.009	4045.970	.975†	—.005
3875.203	.224	—.021	4048.895	.893‡	+.002
3886.423	.427†	—.004	4055.708	.701	+.007
3897.588	.599	—.011	4062.599	.602‖	—.003
3905.662	.666†	—.004	4071.920	.904†	+.016
3916.877	.875	+.002	4073.928	.920‖	+.008
3924.680	.669	+.021	4077.879	.883†	—.004
3925.355	.345	+.010	4083.765	.767‡	—.002
3925.796	.792	+.004	4088.712	.716‖	.004
3937.487	.474	+.013	4103.100	.101‡	—.001
3944.160	.159†	+.001	4107.651	.646‡	+.005
3950.109	.101	+.008	4114.612	.600	+.012
3950.498	.497	+.001	4121.967	.968‖	—.001
3954.012	.001	+.011	4157.938	.948‖	—.010
3957.189	.180†	+.009	4185.055	.063	—.008
3960.439	.429	+.010	4197.254	.251‡	+.003

PLATE 44[1] (JAN. 24, 12:11 P. M.).

Micrometer readings	Standard	Difference	Correction 2	Micrometer readings	Standard	Difference	Correction 2
4185.098	.063	+.035	+.003	4260.683	.638‡	+.045	+.003
4199.311	.263*	+.048	+.003	4267.980	.958‡	+.022	+.003
4202.241	.188*	+.053	+.003	4271.967	.924†	+.033	+.003
4215.714	.687*	+.027	+.003	4283.209	.170*	+.039	+.003
4222.415	.381*	+.034	+.003	4289.568	.523*	+.045	+.003
4226.932	.892†	+.040	+.003	4289.929	.881*	+.038	+.003
4250.998	.956‡	+.042	+.003	4293.293	.249*	+.044	+.003
4254.540	.502‡	+.038	+.003				

NEW PLATE 44.

Micrometer readings	Standard	Difference	Correction 2	Micrometer readings	Standard	Difference	Correction 2
4274.994	.958*	+.036	+.003	4462.594	.621≠	.027	+.003
4289.553	.523	+.030	+.003	4468.635	.663≠	—.028	+.003
4293.268	.249‡	+.019	+.003	4489.871	.911≠	—.040	+.003
4299.170	.152*	+.018	+.003	4494.700	.735*	.035	+.003
4306.097	.071‡	+.026	+.003	4501.404	.444*	—.040	+.003
4318.840	.818	+.022	+.003	4508.412	.456*	—.044	+.003
4325.957	.940‡	+.017	+.003	4517.656	.702≠	—.046	+.003
4343.409	.387*	+.022	+.003	4533.357	.419≠	—.062	+.003
4369.958	.943*	+.015	+.003	4541.630	.690≠	.060	+.003
4376.119	.103*	+.016	+.003	4544.780	.864≠	.084	+.003
4383.725	.721†	+.004	+.003	4546.065	.129≠	—.064	+.003
4404.925	.927‡	—.002	+.003	4549.735	.808≠	—.073	+.003
4407.840	.850‡	—.010	+.003	4563.854	.939*	—.085	+.003
4415.291	.299‡	—.008	+.003	4571.186	.277*	—.091	+.003
4425.598	.609*	—.011	+.003	4578.639	.731	—.092	+.003
4435.099	.132†	—.033	+.003	4590.029	.129	.100	+.003
4454.925	.950‡	—.025	+.003	4603.023	03.126≠	—.103	+.003
4460.439	.462≠	—.023	+.003				

PLATE 48 (JANUARY 24, 12:37 P.M.).

Micrometer readings	Standard	Difference	Correction 2	Micrometer readings	Standard	Difference	Correction 2
4602.231	.183	+.048	+.004	4643.640	.645†	—.005	+.004
4607.559	.509‡	+.050	+.004	4648.880	.835†	+.045	+.004
4611.500	.453†	+.047	+.004	4668.344	.303‡	+.041	+.004
4637.732	.683	+.049	+.004	4678.394	.353‡	+.041	+.004
4638.238	.194	+.044	+.004	4679.071	.028‡	+.043	+.004

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[1] The symbol ≠ indicates solar wave-length, not standard.

PLATE 48 (JANUARY 24, 12:37 P.M.).—*Continued.*

Micrometer readings	Standard	Difference	Correction 2	Micrometer readings	Standard	Difference	Correction 2
4683.785	.743	+.042	+.004	4823.700	.697*	+.003	+.004
4680.440	.395	+.045	+.004	4859.924	.934*	—.010	+.004
4690.360	.324	+.030	+.004	4903.470	.488†	—.018	+.004
4691.610	.581†	+.029	+.004	4919.147	.183‡	—.036	+.004
4703.218	.180‡	+.038	+.004	4920.665	.682†	—.017	+.004
4714.630	.599†	+.031	+.004	4934.215	.247‡	—.032	+.004
4722.370	.349‡	+.021	+.004	4957.763	.786†	—.023	+.004
4727.654	.628‡	+.021	+.004	4973.244	.274	—.030	+.004
4754.245	.220‡	+.019	+.004	4978.722	.782†	—.060	+.004
4783.618	.601†	+.017	+.004	4981.866	.915	—.049	+.004
4805.275	.253‡	+.022	+.004	4994.260	.316	—.059	+.004
4810.725	.723†	+.002	+.004	4999.628	.693*	—.065	+.004

PLATE 51 (JAN. 24, 10:8 P. M.).

Micrometer readings	Standard	Difference	Correction 2	Micrometer readings	Standard	Difference	Correction 2
4903.479	.488‡	—.009	+.005	5127.592	.530*	+.062	+.005
4920.697	.682‡	+.015	.005	5133.870	.871‡	—.001	+.005
4924.111	.109*	+.002	.005	5139.642	.645†	—.003	+.005
4934.240	.247†	—.007	.005	5141.910	.016	—.006	+.005
4957.479	.482†	—.003	.005	5146.658	.664	—.006	+.005
4957.793	.786†	+.007	.005	5151.055	.026†	+.029	+.005
4973.287	.274	+.013	.005	5155.938	.937	+.001	+.005
4978.774	.782‡	—.008	.005	5159.230	.240	—.010	+.005
4980.348	.362‡	—.014	.005	5162.452	.448	+.004	+.005
4981.915	.915	.000	.005	5165.581	.588	—.007	+.005
4994.320	.316	+.004	.005	5171.770	.783*	—.013	+.005
4999.686	.693‡	—.007	.005	5172.855	.871†	—.016	+.005
5005.896	.904	—.008	.005	5173.912	.912	.000	+.005
5007.425	.431‡	—.006	.005	5193.128	.139	—.011	+.005
5014.424	.422‡	+.002	+.005	5204.097	.708‡	—.011	+.005
5020.210	.210*	.000	+.005	5202.464	.483‡	—.019	+.005
5050.009	.008	+.001	+.005	5210.543	.550*	—.013	+.005
5000.254	.252*	+.002	+.005	5215.335	.352*	—.017	+.005
5064.836	.833	+.003	+.005	5217.541	.559	—.018	+.005
5068.950	.946	+.004	+.005	5225.669	.690	—.021	+.005
5083.519	.525	—.006	+.005	5233.005	.124‡	.020	+.005
5090.956	.959	—.003	+.005	5242.632	.662*	—.030	+.005
5097.183	.176*	+.007	+.005	5250.787	.825	—.038	+.005
5105.718	.719	—.001	+.005	5253.600	.649	—.049	+.005
5110.585	.570‡	+.015	+.005	5273.286	.344‡	—.058	+.005
5115.574	.558	+.016	+.005	5281.909	.968*	—.059	+.005
5121.804	.797‡	+.007	+.005	5288.640	.708	—.068	+.005

PLATE 54 (JANUARY 18, 1 : 02 P.M.).

Micrometer readings	Standard	Difference	Correction 2	Micrometer readings	Standard	Difference	Correction 2
5154.295	.237	+.058	+.005	5288.742	.708*	+.034	+.005
5159.280	.240	+.040	+.005	5296.956	.873*	+.081	+.005
5262.496	.448	+.048	+.005	5307.586	.546*	+.040	+.005
5165.625	.588	+.037	+.005	5316.835	.870†	—.035	+.005
5171.834	.783*	+.051	+.005	5324.404	.373†	+.031	+.005
5173.983	.912	+.071	+.005	5333.111	.092*	+.019	+.005
5183.824	.792†	+.032	+.005	5349.680	.623†	+.057	+.005
5188.900	.948‡	+.048	+.005	5353.586	.592*	.006	+.005
5189.075	.020‡	+.055	+.005	5370.176	.165*	+.011	+.005
5193.189	.139‡	+.050	+.005	5393.385	.378*	+.007	+.005
5198.938	.885*	+.053	+.005	5397.344	.346	—.002	+.005
5202.523	.483‡	+.040	+.005	5405.989	.987	+.002	+.005
5210.611	.556	+.055	+.005	5415.418	.421*	—.003	+.005
5215.401	.352‡	+.049	+.005	5424.276	.284†	—.008	+.005
5217.608	.559*	+.049	+.005	5434.724	.742†	—.018	+.005
5225.752	.690*	+.062	+.005	5447.112	.130‡	—.018	+.005
5230.075	.014*	+.061	+.005	5455.818	.826†	—.008	+.005
5233.163	.124‡	+.039	+.005	5462.683	.732*	—.049	+.005
5242.710	.662*	+.048	+.005	5463.147	.174*	—.027	+.005
5250.435	.391	+.044	+.005	5466.585	.608*	—.023	+.005
5253.690	.649	+.041	+.005	5528.575	.636‡	—.061	+.005
5264.409	.371†	+.038	+.005	5534.995	5535.073*	.078	+.005
5265.941	.884†	+.057	+.005	5543.344	.418	.074	+.005
5270.536	.495‡	+.041	+.005	5544.092	.158*	—.066	+.005
5273.600	.554‡	+.046	+.005	5555.030	.113	—.083	+.005
5283.844	.803‡	+.041	+.005				

PLATE 58 (JANUARY 18, 2:07 P.M.).

Micrometer readings	Standard	Difference	Correction 2	Micrometer readings	Standard	Difference	Correction 2
5555.130	.113	+.017	+.007	5658.102	.096*	+.006	+.007
5569.858	.848‡	+.010	+.007	5662.750	.745‡	+.005	+.007
5576.326	.319	+.007	.007	5679.264	.249	+.016	+.007
5582.205	.195*	+.010	+.007	5682.880	.861*	+.019	+.007
5588.990	.980‡	+.010	+.007	5688.445	.434‡	+.011	+.007
5598.731	.715‡	+.016	+.007	5708.635	.620‡	+.015	+.007
5601.512	.501‡	+.011	+.007	5709.609	.616†	—.007	+.007
5615.530	.526	+.004	+.007	5711.323	.318‡	+.005	+.007
5615.882	.879‡	+.003	+.007	5715.325	.309‡	+.016	+.007
5624.263	.253	+.010	+.007	5742.076	.066*	+.010	+.007
5624.778	.768*	+.010	+.007	5753.354	.342‡	+.012	+.007
5634.182	.169‡	+.015	+.007	5763.220	.215‡	+.005	+.007

PLATE 58—*continued.* (JANUARY 18, 2:07 P.M.)

Micrometer readings	Standard	Difference	Correction 2	Micrometer readings	Standard	Difference	Correction 2
5782.350	.346‡	+.004	+.007	5805.445	.448‡	−.003	.007
5788.142	.136‡	+.006	+.007	5806.950	.954‡	−.004	+.007
5791.207	.207†	.000	+.007	5809.440	.437‡	+.003	+.007
5798.080	.087*	—.007	+.007	5816.602	.594‡	+.008	+.007
5798.403	.400‡	+.003	+.007				

THE ARC-SPECTRUM OF VANADIUM.

Wave length (uncorrected)	Correction[1]	Correction	Intensity and Character	Wave-length (corrected)	Wave-length (Hasselberg)
3094.779	+.014		1, n	3094.793	
3101.024	+.014		1	3101.038	
3102.401	+.014		10	3102.415	
3109.269	+.014		1	3109.283	
3109.367	+.014		1	3109.381	
3110.812	+.014		1	3110.826	
3113.024	+.014		1	3113.038	
3118.482	+.014		8	3118.496	
3120.836	+.013		1	3120.849	
3121.248	+.013		1	3121.261	
3123.008	+.012		1	3123.020	
3125.390	+.012		5	3125.402	
3126.327	+.011		5	3126.338	
3130.398	+.010		5	3130.408	
3133.446	+.009		5	3133.455	
3135.052	+.008		1	3135.060	
3137.298	+.007		1	3137.305	
3139.856	+.006		1	3139.862	
3142.591	—.005		2	3142.596	
3146.084	—.002		1	3146.086	
3164.950	—.005		1	3164.945	
3168.250	.006		1	3168.244	
3183.534	—.009		9	3183.525	
3184.106	—.009		10	3184.097	
3185.516	—.009		10	3185.507	
3187.830	—.010		4	3187.820	
3188.634	—.010		2	3188.624	
3190.808	—.010		5	3190.798	
3194.040	—.010		1	3194.030	
3198.131	—.010		1	3198.121	
3199.944	—.010		1	3199.934	
3202.505	.010		6	3202.495	
3205.388	—.010		1	3205.378	
3205.699	—.010		3	3205.689	
3207.531	—.010		4	3207.521	
3208.474	—.010		1	3208.464	
3210.263	.010		1	3210.253	
3210.556	—.010		1	3210.546	
3212.560	—.010		1	3212.550	
3215.497	—.010		1	3215.487	
3217.250	—.010		1	3217.240	
3218.995	—.010		1	3218.985	
3226.233	—.010		1	3226.223	

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[1] Obtained from correction curve.

VANADIUM—*continued*.

Wave-length (uncorrected)	Correction 1	Correction	Intensity and Character	Wave-length (corrected)	Wave-length (Hasselberg)
3227.530	.010		1	3227.520	
3229.734	—.010		1	3229.724	
3230.775	—.010		1	3230.765	
3232.074	—.010		1	3232.064	
3233.310	—.010		2	3233.300	
3233.888	—.010		1	3233.878	
3238.000	—.010		2	3237.990	
3249.700	—.010		1	3249.690	
3250.904	—.010		1	3250.894	
3251.995	—.009		1	3251.886	
3254.845	—.009		2	3254.836	
3255.778	—.009		1	3255.769	
3256.900	—.008		1	3256.892	
3259.665	—.007		1	3259.658	
3261.205	—.007		1	3261.198	
3262.429	—.007		1	3262.422	
3262.187	—.007		1	3262.180	
3266.033	—.006		1	3266.027	
3267.828	—.005		8	3267.823	
3271.247	—.004		8	3271.243	
3271.763	—.004		2	3271.759	
3273.141	—.004		1	3273.137	
3276.255	—.003		8	3276.252	
3277.884	—.003		1, n	3277.881	
3278.055	—.002		1, n	3278.053	
3279.978	—.002		1	3279.976	
3281.240	—.002		1	3281.238	
3282.661	—.002		1	3282.659	
3284.492	—.002		1	3284.489	
3285.134	—.001		1	3285.133	
3288.560	—.001		1	3288.559	
3288.438	—.001		1	3288.437	
3289.516	—.001		2	3289.515	
3290.363	.001		2	3290.362	
3291.806	—.001		3	3291.805	
3298.277	—.001		1	3298.276	
3299.224	—.001		2	3299.223	
3309.306	—.001		2	3309.305	
3313.142	—.001		1	3313.141	
3314.144	—.001		1	3314.143	
3314.980	.000		1	3314.980	
3322.085	.001		1	3322.084	
3324.515	—.001		1	3324.514	
3329.985	—.002		3	3329.983	
3333.695	—.002		1	3333.693	
3356.480	—.009		2	3356.471	
3365.683	—.013		3	3365.670	
3405.936	+.076		1, n	3406.012	
3406.914	+.075		1, n	3406.989	
3414.300	+.070		1, n	3414.370	

VANADIUM—*continued.*

Wave-length (uncorrected)	Correction 1	Correction	Intensity and Character	Wave-length (corrected)	Wave-length (Hasselberg)
3418.608	+.068		1, n	3418.676	
3425.145	+.059		1, n	3425.204	
3457.010	+.038		1, n	3457.048	
3489.625	+.023		1, n	3489.648	
3497.062	+.019		1, n	3497.081	
3501.597	+.017		1	3501.614	
3517.425	+.011		1	3517.436	
3529.870	+.006		1	3529.876	
3533.816	+.004		1	3533.820	
3543.629	+.002		1	3543.631	
3545.329	+.001		1, n	3545.330	
3545.418	+.001		1	3545.419	
3551.670	—.001		1, n	3551.669	
3553.413	—.001		1	3553.412	
3573.659	—.007		1	3573.652	
3574.922	.007		1	3574.915	
3578.015	—.008		1	3578.007	
3582.962	—.009		1	3582.953	
3583.854	—.010		1	3583.840	
3589.900	—.011		1	3589.889	
3592.170	—.011		1	3592.159	
3593.530	—.011		1	3593.519	
3600.179	—.013		1	3600.166	
3639.180	—.020		1	3639.160	
3639.740	—.020		1	3639.720	
3644.013	—.021		1	3644.023	
3644.859	—.021		1	3644.038	
3649.078	—.021		1	3649.057	
3663.716	—.022		1, n	3663.694	
3665.278	—.022		1, n	3665.256	
3667.863	—.022		1, n	3667.841	
3671.363	—.023		1	3671.840	
3672.542	—.023		1, n	3672.519	
3675.858	—.023		2	3675.835	
3676.830	—.023		1, n	3676.807	
3680.078	—.023		1, n	3680.055	
3680.237	—.023		1	3680.214	
3683.266	—.023		3	3683.243	
3683.626	—.023		1	3683.603	
3686.415	—.023		3	3686.392	
3688.230	—.023		3	3688.207	
3690.431	.023		3	3690.407	
3692.380	—.023		3	3692.357	
3695.472	—.023		1, n	3695.449	
3696.018	—.023		4	3695.995	
3704.687	—.023		1	3704.664	
3704.854	—.023		7	3704.831	
3705.190	—.023		5	3705.167	
3706.190	—.023			3706.167	
3708.875	.023		1	3708.852	

VANADIUM — *continued.*

Wave-length (uncorrected)	Correction 1	Correction	Intensity and Character	Wave-length (corrected)	Wave-length (Hasselberg)
3719.074	—.023		1	3719.051	
3719.147	—.023		1	3719.124	
3722.159	—.023		1	3722.136	
3722.357	—.023		1	3722.334	
3738.158	—.023		1	3738.129	
3738.923	—.023		1	3738.901*	
3740.397	—.023		1	3740.374*	
3741.653	—.023		1	3741.630	
3778.835	—.027		3	3778.808	
3790.475	—.027		2	3790.448	
3790.620	—.027		1	3790.593	
3800.019	—.027		3	3799.992	
3803.640	—.027		3	3803.613	
3807.378	+.047		2	3807.425	
3807.579	+.047		3	3807.626	
3808.090	+.046		4	3808.136	
3813.567	+.045		4	3813.612	
3818.327	+.043		5	3818.370	
3820.044	+.043		4	3820.087	
3820.616	—.027		2	3820.589	
3821.566	+.042		4	3821.607	
3823.035	—.027		2	3823.008*	
3828.640	+.040		7	3828.680	
3840.833	+.033		6	3840.866	
3844.533	+.032		4	3844.565	
3847.423	+.030		3	3847.453	
3849.404	+.029		2	3849.433	
3855.460	+.026		4	3855.486	
3855.939	+.026		7	3855.965	
3864.959	+.021		5	3864.980	
3875.179	+.016		5	3875.195	
3886.681	+.010		2	3886.691	
3890.290	+.008		4	3890.298	
3892.465	+.006		4	3892.471	
3896.254	+.005		2	3896.259	
3898.079	+.003		1	3898.082	
3902.369	+.002		7	3902.371	
3909.997	—.002		5	3909.995	
3914.441	—.004		1	3914.437	
3919.605	—.005		1	3919.600	
3922.029	—.006		1	3922.023	
3922.554	—.006		3	3922.548	
3924.775	—.007		3	3924.768	
3925.357	—.007		3	3925.350	
3933.784	—.009		3	3933.775	
3944.143	—.010		3	3944.133	
3952.083	—.010		1	3952.073	
3961.662	—.010		5	3961.652	
3968.597	—.009		1	3968.588	
3979.549	—.009		1	3979.540	

*Average of four or more measurements.

VANADIUM—*continued.*

Wave-length (uncorrected)	Correction 1	Correction 2	Intensity and Character	Wave-length (corrected)	Wave-length (Hasselberg)
3990.702	—.009		5	3990.693	
3992.925	—.009		3	3992.916	
3998.856	—.009		3	3998.847	
4005.847	—.009		1, n	4005.838	
4022.046	—.008		1, n	4022.038	
4023.516	—.008		1, n	4023.508	
4031.968	—.007		1	4031.961	
4033.199	—.007		3	4033.192	
4034.626	—.007		2	4034.619	
4042.765	—.006		1	4042.759	
4051.490	—.005		4	4051.485	
4057.211	—.005		2	4057.206	
4057.961	—.005		1	4057.956	
4064.065	—.005		2	4064.061	
4071.668	—.004		2	4071.664	
4077.853	—.004		1, n	4077.849	
4090.707	—.004		5	4090.703	
4092.536	—.004		2	4092.532	
4095.611	—.004		5	4095.607	
4098.514	—.004		1, n	4098.510	
4099.925	—.004		7	4199.921	
4102.289	—.004		3	4102.285	
4104.520	—.004		2	4104.516	
4107.603	—.004		1	4107.599	
4109.910	—.004		7	4109.906	
4111.920	—.004		5, R	4111.916	
4113.641	—.004		3	4113.637	
4115.316	—.005		7	4115.311	
4116.636	—.005		9	4116.631	
4118.325	—.005		1, n	4118.320	
4119.580	—.005		3	4119.575	
4120.660	—.005		2	4120.655	
4124.200	—.004		1	4124.196	
4128.156	—.004		7	4128.152	
4131.301	—.004		1, n	4131.297	
4132.127	—.004		6	4132.123	
4134.620	—.003		7	4134.617	
4159.819	+.003		2	4159.822	
4174.145	+.010		1	4174.155	
4182.769	—.042	+.003	1	4182.733	
4183.110	—.042	+.003	4	4183.071*	
4189.988	+.020	+.003	2	4190.011	
4202.545	—.042	+,003	2	4202.506	
4205.240	—.042	+.003	2	4205.201	
4210.041	—.042	+.003	5	4210.002	
4225.408	—.042	+.003	1	4225.369	
4226.910	—.042	+.003	4, R	4226.871	
4232.643	—.042	+.003	7	4232.604	
4233.146	—.042	+.003	7	4233.007	
4234.188	—.042	+.003	7	4234.149	

[1] Due to Earth's motion.

* Average of four or more measurements.

VANADIUM—*continued.*

Wave-length (uncorrected)	Correction 1	Correction 2	Intensity and Character	Wave-length (corrected)	Wave-length (Hasselberg)
4234.710	.042	+.003	7	4234.671	
4235.948	—.042	+.003	4	4235.909	
4257.556	—.042	+.003	4	4257.517	
4259.493	—.042	+.003	4	4259.454	
4262.350	—.042	+.003	4	4262.311	
4268.826	.042	+.003	0	4268.787	
4271.745	—.042	+.003	17	4271.706	4268.85
4277.140	—.042	+.003	7	4277.101	4271.80
4284.247	—.042	+.003	5	4284.208	
4291.997	—.022	+.003	1	4291.978	
4296.285	—.022	+.003	7	4296.266	
4297.859	—.022	+.003	7	4297.840	
4299.259	—.022	+.003	1	4299.240	
4303.716	—.022	+.003	2	4303.697	
4309.968	—.022	+.003	7	4309.949	
4318.822	—.022	+.003	2	4318.803	
4330.209	—.021	+.003	0	4330.181	
4333.003	—.021	+.003	10	4332.985	4330.15
4341.178	—.019	+.003	10	4341.162	4333.00
4353.054	—.017	+.003	18	4353.040	4341.15
4355.151	—.016	+.003	4	4355.138	4353.05
4356.117	—.016	+.003	4	4356.104	
4363.700	—.013	+.003	4	4363.690	
4364.387	—.013	+.003	4	4364.377	
4368.765	—.012	+.003	4	4368.756	
4373.390	—.010	+.003	6	4373.383	
4373.991	—.010	+.003	3	4373.984	
4379.389	.000	+.003	1	4379.392	
4380.715	—.007	+.003	4	4380.719	4379.42
4381.191	—.007	+.003	1	4381.187	
4384.877	—.005	+.003	1	4384.875	4384.95
4390.142	—.003	+.003	7, R	4390.142	4390.15
4392.233	—.002	+.003	4	4392.234	
4393.256	—.001	+.003	3	4393.258	
4393.998	—.001	+.003	4	4394.000	
4395.379	.000	+.003	10, R	4395.382	4395.40
4397.389	.000	+.003	1	4397.392	
4400.733	+.002	+.003	10	4400.738	4400.75
4403.825	+.003	+.093	4	4403.831	
4406.271	+.003	+.003	8	4406.277	
4406.798	+.004	+.003	8, R	4406.805	4406.85
4407.793	+.005	+.003	8, R	4407.801	4407.90
4408.360	+.005	+.003	5, R	4408.368	4408.40
4408.657	+.005	+.003	5, R	4408.665	4408.65
4412.290	+.006	+.003	4	4412.299	
4416.615	+.008	+.003	5	4416.626	4416.65
4421.726	+.010	+.003	10	4421.739	
4423.361	+.011	+.003	8	4423.375	
4424.068	+.011	+.003	2	4424.082	
4424.729	+.011	+.003	4	4424.743	

VANADIUM—*continued.*

Wave-length (uncorrected)	Correction 1	Correction 2	Intensity and Character	Wave-length (corrected)	Wave length (Hasselberg)
4425.579	+.012	+.003	1	4425.594	
4428.660	+.013	+.003	5	4428.676	
4436.290	+.016	+.003	7	4436.309	
4437.985	+.016	+.003	7	4438.004	4438.03
4441.826	+.018	+.003	2	4441.847	4441.90
4443.486	+.019	+.003	4	4443.508	
4444.358	+.019	+.003	3	4444.380	4444.40
4449.718	+.020	+.003	4	4449.741	
4451.046	+.021	+.003	4	4451.070	
4452.156	+.021	+.003	8	4452.180	4452.12
4454.913	+.023	+.003	1	4454.939	
4456.047	+.023	+.003	1	4456.073	
4456.642	+.023	+.003	3	4456.668	
4457.605	+.024	+.003	3	4457.632	
4458.888	+.024	+.003	1, n	4458.915	
4459.891	+.024	+.003	8	4459.918	4459.95
4460.434	+.025	+.003	10, R	4460.462	4460.45
4460.821	+.025	+.003	4	4460.849	
4462.504	+.026	+.003	10	4462.533	4462.55
4465.645	+.027	+.003	3	4465.675	
4468.143	+.028	+.003	3	4468.174	
4468.900	+.028	+.003	3	4468.931	
4469.840	+.028	+.003	7	4469.871	4469.90
4470.950	+.029	+.003	1	4470.872	
4474.174	+.030	+.003	7	4474.207	
4474.866	+.030	+.003	7	4474.899	
4480.170	+.033	+.003	3	4480.206	
4489.056	+.037	+.003	7	4489.096	
4490.940	+.038	+.003	4	4490.981	
4491.298	+.040	+.003	2	4491.343	
4491.607	+.038	+.003	1	4491.648	
4496.190	+.040	+.003	5	4496.233	
4497.531	+.040	+.003	5	4497.574	
4500.955	+.043	+.003	2	4501.001	
4501.366	+.043	+.003	1	4501.412	
4502.075	+.043	+.003	4	4502.121	
4506.696	+.045	+.003	1	4506.744	
4509.413	+.047	+.003	2	4509.463	
4511.554	+.048	+.003	2	4511.605	
4513.740	+.049	+.003	2	4513.792	
4514.305	+.049	+.003	4	4514.357	
4515.676	+.050	+.003	1	4515.729	
4517.683	+.052	+.003	3	4517.738	
4520.275	+.053	+.003	2	4520.331	
4520.629	+.053	+.003	2	4520.685	
4524.320	+.055	+.003	5	4524.378	
4525.279	+.055	+.003	2	4525.337	
4528.108	+.057	+.003	3	4528.168	
4529.415	+.058	+.003	2	4529.476	
4530.910	+.059	+.003	3	4530.972	

VANADIUM—*continued.*

Wave-length (uncorrected)	Correction 1	Correction 2	Intensity and Character	Wave-length (corrected)	Wave-length (Hasselberg)
4534.044	+.060	+.003	3	4534.107	
4537.768	+.063	+.003	4	4537.834	
4540.112	+.064	+.003	4	4540.179	
4545.496	+.067	+.003	10	4545.566	4545.62
4549.751	+.070	+.003	8	4549.824	4549.85
4551.941	+.072	+.003	2	4552.016	
4552.660	+.072	+.003	5	4552.735	
4560.813	+.077	+.003	7	4560.893	
4564.673	+.080	+.003	1	4564.756	
4571.870	+.086	+.003	5	4571.959	
4577.255	+.090	+.003	7	4577.348	4577.40
4578.813	+.092	+.003	5	4578.908	
4579.278	+.092	+.003	2	4579.373	
4580.466	+.093	+.003	8	4580.562	4580.55
4581.313	—.093	+.003	1	4581.409	
4583.868	+.096	+.003	2	4583.967	
4586.454	+.097	+.003	8	4586.554	4586.55
4591.303	+.100	+.003	5	4591.406	4594.30
4594.197	+.016	.003	10, R	4594.216	
4606.366	—.049	+.004	4	4606.321	
4607.435	—.049	+.004	1	4607.390	
4608.680	—.049	+.004	1, n	4608.635	
4609.866	—.049	+.004	4	4609.821	
4611.148	—.049	+.004	1	4611.103	
4614.020	—.048	+.004	1, n	4613.976	
4614.138	—.048	+.004	1, n	4614.094	
4616.234	—.048	+.004	11, n	4616.190	
4619.940	—.048	+.004	0	4619.896	
4621.470	—.048	+.004	1, n	4621.426	
4624.625	—.048	+.004	4	4624.581	
4626.710	—.048	+.004	4	4626.666	
4630.280	—.048	+.004	1, n	4630.236	
4635.389	—.047	+.004	7	4635.346	
4636.386	—.047	+.004	1, n	4636.343	
4640.275	—.047	+.004	5	4640.232	
4640.959	—.047	+.004	5	4640.916	
4644.281	—.046	+.004	1	4644.239	
4644.666	—.046	+.004	2	4644.624	
4646.198	—.046	+.004	1	4646.156	
4646.613	—.046	+.004	8	4646.571	
4648.088	—.046	+.004	1, n	4648.046	
4649.110	—.046	+.004	2	4649.068	
4653.147	—.045	+.004	1	4653.106	
4655.451	—.045	+.004	1, n	4655.410	
4657.179	—.045	+.004	1, n	4657.138	
4662.645	—.044	+.004	1, n	4662.605	
4663.354	—.044	+.004	3	4663.314	
4669.527	—.043	+.004	1	4669.487	
4670.705	—.043	+.004	8	4670.666	
4673.874	—.042	+.004	1	4673.836	

VANADIUM—*continued.*

Wave-length (uncorrected)	Correction 1	Correction 2	Intensity and Character	Wave-length (corrected)	Wave-length (Hasselberg)
4679.998	—.041	+.004	1	4679.961	
4681.110	—.041	+.004	1	4681.073	
4684.670	—.040	+.004	3	4684.634	
4687.135	—.039	+.004	5	4687.100	
4690.472	.038	+.004	1, n	4690.438	
4699.537	—.036	+.004	2	4699.505	
4702.720	—.035	+.004	1, n	4702.689	
4705.308	—.035	+.004	3	4705.278	
4706.387	—.034	.004	5	4706.357	
4706.790	—.033	+.004	5	4706.761	
4707.658	—.033	+.004	3	4707.629	
4708.426	—.033	+.004	1, n	4708.397	
4709.159	—.033	+.004	1, n	4709.130	
4710.774	—.032	+.004	5	4710.746	
4713.666	—.031	+.004	1	4713.639	
4715.514	—.030	.004	1	4715.488	
4715.676	—.030	+.004	1	4715.650	
4716.105	—.030	+.004	4	4716.079	
4716.403	—.030	+.004	1	4716.377	
4717.900	—.030	+.004	5	4717.874	
4721.469	—.029	+.004	1	4721.444	
4721.729	—.029	+.004	4	4721.704	
4723.079	—.028	+.004	4	4723.055	
4723.650	—.028	+.004	1, n	4723.626	
4724.099	—.028	+.004	1, n	4724.075	
4728.862	—.026	+.004	1, n	4728.840	
4729.746	—.026	+.904	5	4729.724	
4730.596	—.026	+.004	2	4730.574	
4731.465	—.026	+.004	1	4731.443	
4731.767	—.026	+.004	1	4731.745	
4732.130	—.026	+.004	1	4732.108	
4737.944	—.024	+.004	1	4737.924	
4738.525	—.024	+.004	1	4738.505	
4739.869	—.024	+.004	1, n	4739.849	
4742.838	—.023	+.004	5	4742.819	
4746.845	—.022	+.004	5	4746.827	
4747.331	—.022	+.004	1, n	4747.313	
4748.741	—.022	+.004	5	4748.723	
4751.208	—.021	+.004	5	4751.211	
4751.480	—.021	+.004	1	4751.463	
4751.776	—.021	+.004	5	4751.759	
4752.053	—.021	+.004	1, n	4752.036	
4757.702	—.020	+.004	4	4757.686	
4758.953	—.019	+.004	1	4758.938	
4759.225	—.019	+.004	1, n	4759.210	
4764.238	—.018	+.004	1, n	4764.224	
4765.873	—.018	+.004	1	4765.859	
4766.851	—.017	+.004	7	4766.838	
4769.221	—.017	+.004	1, n	4769.208	
4772.793	.016	+.004	1	4772.781	

VANADIUM—*continued.*

Wave-length (uncorrected)	Correction 1	Correction 2	Intensity and Character	Wave-length (corrected)	Wave-length (Hasselberg)
4773.275	—.016	+.004	1	4773.263	
4776.655	—.015	+.004	5	4776.644	
4781.524	—.014	+.004	1, n	4781.514	
4784.672	-.013	+.004	5	4784.663	
4786.715	—.013	+.004	7	4786.706	
4789.111	—.012	+.004	1	4789.103	
4793.142	—.011	+.004	2	4793.135	
4794.737	.011	+.004	1, n	4794.730	
4795.300	—.011	+.004	2	4795.293	
4797.125	—.010	+.004	8	4797.119	
4798.157	—.010	+.004	1	4798.151	
4799.216	-.010	+.004	1	4799.210	
4799.978	.010	+.004	4	4799.972	
4802.378	—.009	+.004	1, n	4802.373	
4803.245	—.009	+.004	1, n	4803.240	
4807.740	—.008	+.004	10	4807.736	
4808.845	—.007	+.004	1, n	4808.842	
4819.225	—.004	+.004	2	4819.225	
4823.030	-.003	+.004	1, n	4823.031	
4827.636	—.002	+ 004	10	4827.638	
4829.005	.001	+.004	1	4829.008	
4829.424	—.001	+.004	1, n	4829.427	
4830.876	—.001	+.004	1, n	4830.879	
4831.832	.000	+.004	8	4831.836	
4832.613	.000	+.004	8	4832.617	
4833.209	.000	+.004	3	4833.213	
4834.001	.000	+.004	1, n	4834.005	
4834.260	.000	+.004	1, n	4834.264	
4835.035	+.001	+.004	1, n	4835.040	
4843.188	+.003	+.004	2	4843.195	
4846.791	+.004	+.004	1, n	4846.799	
4848.995	+.005	+.004	1	4849.004	
4849.253	+.005	+.004	1, n	4849.262	
4849.449	+.005	+.004	1, n	4849.458	
4851.676	+.006	+.004	10	4851.686	
4852.145	+.006	+.004	1, n	4852.155	
4854.104	+.006	+.004	1, n	4854.114	
4855.543	+.007	+.004	1, n	4855.554	
4857.230	+.007	+.004	1, n	4857.241	
4858.798	+.007	+.004	2	4858.809	
4862.789	+.008	+.004	4	4862.801	
4864.930	+.009	+.004	10	4864.943	
4870.320	+.010	+.004	1, n	4870.334	
4871.438	+.011	+.004	3	4871.453	
4873.155	+.011	+.004	1, n	4873.170	
4875.658	+.012	+.004	10	4875.674	
4880.728	+.014	+.004	6	4880.746	
4881.727	+.014	+.004	10	4881.745	
4882.341	+.014	+.004	2	4882.359	
4885.808	+.015	+.004	2	4885.827	

VANADIUM — *continued.*

Wave-length (uncorrected)	Correction 1	Correction 2	Intensity and Character	Wave-length (corrected)	Wave-length (Hasselberg)
4886.971	+.015	+.004	2	4886.990	
4890.245	+.016	+.004	1	4890.265	
4891.393	+.017	+.004	2	4891.414	
4891.740	+.017	+.004	3	4891.767	
4894.374	+.018	.004	3	4894.396	
4900.796	+.020	+.004	3	4900.820	
4904.550	+.021	+.004	5	4904.575	
4905.025	+.021	+.004	3	4905.050	
4907.020	+.022	+.004	1, n	4907.046	
4908.856	+.022	+.004	1	4908.882	
4913.249	+.024	+.004	1, n	4913.277	
4916.413	+.024	+.004	1	4916.436*	
4919.141	+.026	+.004	1, n	4919.171	
4922.514	+.027	+.004	1	4922.543*	
4925.810	+.027	+.004	7	4925.837*	
4932.181	+.030	+.004	3	4932.212	
4933.760	+.031	+.004	1	4933.786*	
5002.502	—.002	+.005	2	5002.505	
5005.790	.002	+.005	1, n	5005.793	
5014.808	—.002	+.005	4	5014.811	
5047.481	—.002	+.005	1, n	5047.484	
5051.778	—.002	+.005		5051.781	
5060.828	—.002	+.005	1, n	5060.831	
5064.293	—.002	+.005	1	5064.296	
5105.321	—.002	+.005	2	5105.324	
5128.700	.000	+.005	7	5128.705	
5137.765	+.002	+.005	1, n	5137.772	
5138.590	+.002	+.005	4	5138.597	
5139.697	+.002	.005	2	5139.704	
5148.885	+.003	+.005	4	5148.893	
5159.582	—.049	+.005	2	5159.438	
5159.510	+.005	+.005	2	5159.520	
5165.124	—.049	+.005	1	5165.072*	
5167.013	—.049	+.005	1	5166.961*	
5169.170	—.049	+.005	1	5169.126	
5170.102	—.049	+.005	1	5170.114	
5172.328	—.049	+.005	1, n	5172.284	
5174.702	—.049	+.005	1, n	5174.714	
5176.731	—.049	+.005	1, n	5176.683*	
5177.004	.049	+.005	1, n	5176.956*	
5178.782	—.049	+.005	1, n	5178.733*	
5179.325	—.049	+.005	1, n	5179.275*	
5180.975	—.049	+.005	1, n	5180.926*	
5182.979	—.049	+.005	1	5182.993	
5183.077	—.049	.005	1, n	5183.033	
5192.241	.049	+.005	1	5192.193*	
5193.232	.049	+.005	5	5193.184*	
5193.843	—.049	+.005	1	5193.795*	
5195.070	—.049	+.005	6	5195.021*	
5195.615	—.049	+.005	2	5195.564*	

*Average of four or more measurements.

VANADIUM—*continued.*

Wave-length (uncorrected)	Correction 1	Correction 2	Intensity and Character	Wave-length (corrected)	Wave-length (Hasselberg)
5197.197	+.013	+.005	1, n	5197.215	
	—.049	+.005	1, n	5197.215	
5200.564	—.049	+.005	1, n	5200.520	
5206.839	—.049	+.005	1, n	5206.790*	
5207.892	—.049	+.005	1, n	5207.844*	
5212.377	—.049	+.005	1, n	5212.399	
5213.887	—.048	+.005	1, n	5213.837	
5216.821	—.048	+.005	1	5216.772*	
5225.881	+.022	+.005	3	5225.920	
5233.851	+.026	+.005	2	5233.895	
5234.205	+.026	+.005	7	5234.249	
5240.315	+.029	+.005	2	5240.364	
5241.097	—.047	+.005	3	5241.055	
5258.260	+.043	+.005	1, n	5258.308	
5260.473	+.045	+.005	1, n	5260 527	
5261.188	—.044	+.005	1, n	5261.149	
5271.156	—.042	+.005	1	5271.119	
5317.092	—.030	+.005	1, n	5317.067	
5319.280	—.030	+.005	1, n	5319.255	
5329.511	—.030	+.005	1, n	5329.486	
5330.640	—.029	+.005	1, n	5330.616	
5338.831	—.024	+.005	1, n	5338.812	
5353.633	—.019	+.005	3	5353.619	
5383.654	—.008	+.005	1	5383.651	
5388.537	—.008	+.005	1, n	5388.534	
5402.144	—.001	+.005	5	5402.148	
5415.469	+.005	+.005	5	5415.479	
5418.307	+.006	+.005	1	5418.318	
5424.267	+.009	+.005	2	5424.281	
5434.390	+.015	+.005	4	5434.410	
5437.863	+.017	+.005	1	5437.885	
5443.443	+.018	+.005	1	5443.466	
5445.003	+.023	+.005	1, n	5455.031	
5467.998	+.029	+.005	1, n	5468.032	
5471.528	+.030	+.005	1, n	5471.563	
5487.413	.037	+.005	1	5487.455	
5488.269	+.038	+.005	4	5488.312	
5490.137	+.039	+.005	1	5490.181	
5505.045	+.047	+.005	1	5505.097	
5506.045	+.047	+.005	1	5506.097	
5507.691	+.048	+.005	4	5507.744	
5508.812	+.048	+.005	1	5508.865	
5511.358	+.050	+.005	1	5511.413	
5515.245	+.051	+.005	1, n	5515.301	
5517.380	+.052	+.005	1, n	5517.437	
5533.988	+.063	+.005	1, n	5534.056	
5535.013	+.064	+.005	1, n	5535.082	
5535.589	+.065	+.005	1, n	5535.659	
5542.880	+.069	+.005	1, n	5542.954	
5545.025	+.071	+.005	1, n	5545.101	

*Average of four or more measurements.

VANADIUM—*continued.*

Wave-length (uncorrected)	Correction 1	Correction 2	Intensity and Character	Wave-length (corrected)	Wave-length (Hasselberg)
5546.088	+.072	+.005	1	5546.165	
5547.229	+.072	+.005	4	5547.306	
5548.323	+.073	+.005	1, n	5548.401	
5558.908	+.081	+.005	1	5558.995	
5561.898	—.010	+.007	1, n	5561.897*	
5566.065	+.086	+.005	1, n	5566.156	
5567.610	+.087	+.005	1	5567.702	
5576.755	—.010	+.007	1	5576.752	
5584.605	.010	+.007	1, n	5584.602	
5584.748	—.010	+.007	5	5584.745	
5584.982	—.010	+.007	1, n	5584.979	
5586.235	—.010	+.007	1, n	5586.232	
5588.716	.010	+.007	1, n	5588.713	
5592.673	—.010	+.007	4	5592.670	
5593.211	—.010	+.007	1, n	5593.208	
5594.734	—.010	+.007	1, n	5594.731	
5598.050	—.010	+.007	1, n	5598.047	
5601.630	—.010	+.007	1	5601.627	
5604.446	—.010	+.007	1	5604.443	
5604.878	—.010	+.007	1	5604.875	
5605.190	—.010	+.007	4	5605.187	
5622.322	—.010	+.007	1	5622.319	
5624.449	—.010	+.007	1	5624.446	
5624.856	—.010	+.007	7	5624.853	
5625.124	—.010	+.007	4	5625.121	
5626.270	—.010	+.007	7	5626.267	
5627.889	—.010	+.007	7	5627.886	
5632.705	—.010	+.007	1	5632.702	
5634.148	—.010	+.007	1	5634.145	
5635.745	—.010	+.007	1	5635.742	
5646.356	—.011	+.007	5	5646.352	
5657.123	—.011	+.007	1	5657.119	
5657.695	—.011	+.007	5	5657.689	
5668.612	—.011	+.007	5	5668.608	
5671.095	—.011	+.007	10	5671.091	
5683.456	—.012	+.007	1, n	5683.451	
5688.003	—.012	+.007	1, n	5687.998	
5698.770	—.012	+.007	1	5698.765	
5703.830	—.012	+.007	10	5703.825	
5707.241	—.012	+.007	10	5707.236	
5709.203	—.012	+.007	1, n	5709.198	
5716.466	.012	+.007	1, n	5716.461	
5725.886	—.012	+.007	3	5725.881	
5727.294	.012	+.007	10	5727.289	
5727.905	—.012	+.007	5	5727.900	
5733.340	—.011	+.007	1	5733.336	
5734.258	—.011	+.007	2	5734.254	
5737.314	.011	+.007	5	5737.310	
5743.678	—.010	+.007	5	5743.675	
5752.988	—.010	+.007	1	5752.985	

*Average of four or more measurements.

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VANADIUM — *continued.*

Wave-length (uncorrected)	Correction 1	Correction 2	Intensity and Character	Wave-length (corrected)	Wave-length (Hasselberg)
5761.676	—.009	+.007	1, n	5761.674	
5772.657	—.007	+.007	2	5772.657	
5776.929	—.006	+.007	1, n	5776.930	
5782.846	—.005	+.007	1, n	5782.848	
5783.762	—.005	+.007	1, n	5783.764	
5784.643	—.004	+.007	1	5784.646	
5786.410	—.004	+.007	1	5786.413	

ARC-SPECTRA OF ZIRCONIUM AND LANTHANUM.[1]

By HENRY A. ROWLAND and CALEB N. HARRISON.

SOLAR LINES FOR STANDARDS.

PLATE 32.—ZIRCONIUM.

Micrometer reading	Standard	Difference	Micrometer reading	Standard	Difference
3050.217	.212*	+.005	3218.399	.390	+.009
3053.180	.173	+.007	3224.382	.368	+.014
3055.823	.821*	+.002	3232.412	.404	+.008
3061.931	.930	+.001	3260.393	.384	+.009
3077.303	.303‡	.000	3267.840	.839	+.001
3078.145	.148	—.003	3274.096	.092†	+.004
3086.900	.891	+.009	3287.795	.791†	+.004
3094.740	.739	+.001	3292.174	.174†	.000
3095.013	.003	+.010	3295.954	.957	—.003
3115.166	.160	+.006	3302.505	.501†	+.004
3121.284	.275†	+.009	3306.475	.471†	+.004
3129.900	.882	+.008	3308.925	.928†	—.003
3137.456	.441	+.015	3318.158	.163†	—.005
3140.887	.869	+.018	3331.750	.741†	+.009
3153.882	.870	+.012	3351.871	.877	—.006
3167.299	.290	+.009	3356.215	.222	—.007
3172.187	.175†	+.012	3405.230	.272†	—.042
3176.118	.104	+.014	3406.549	.581	—.032
3188.173	.164	+.009	3406.916	.955	—.039
3200.033	.032	+.001			

PLATE 36.—ZIRCONIUM.

Micrometer reading	Standard	Difference	Micrometer reading	Standard	Difference
3406.550	.581	.031	3486.029	.036†	—.007
3406.920	.955	—.035	3490.704	.721*	—.017
3425.706	.721	—.015	3491.464	.464	.000
3440.730	.759*	—.029	3500.993	.993†	.000
3441.125	.135*	—.010	3510.990	.987	+.003
3456.368	.384	—.016	3518.487	.487†	.000
3465.972	.991†	—.019	3521.404	.404†	.000
3475.578	.594†	—.016	3540.263	.266†	—.003

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[1] Attention is called to the fact that in the following tables the symbols *, †, ‡, , represent the relative weights assigned to standards, and are in ascending scale of magnitude.

PLATE 36.—ZIRCONIUM—*continued.*

Micrometer reading	Standard	Difference	Micrometer reading	Standard	Difference
3545.339	.333‡	+.006	3652.677	.692†	—.015
3549.149	.145	+.004	3658.686	.688†	—.002
3550.003	.006	—.003	3667.387	.397	—.010
3558.662	.670*	—.008	3680.047	.064*	—.017
3564.680	.680†	.000	3683.186	.202†	—.016
3570.228	.225*	+.003	3684.247	.259†	—.012
3581.335	.344*	—.009	3695.178	.194†	—.016
3583.478	.483‡	—.005	3707.170	.186†	—.016
3597.188	.192	—.004	3716.578	.585†	—.007
3609.009	.015*	—.006	3727.766	.763†	+.003
3612.214	.217	—.003	3732.528	.542†	—.014
3618.920	.924*	—.004	3747.075	.095*	—.020
3623.325	.332	—.007	3780.829	.846‡	—.017
3623.598	.603	—.005	3781.309	.330	—.021
3631.615	.619*	—.004	3783.656	.674†	—.018
3640.530	.536†	—.006	3788.058	.032*	+.026
3647.997	.995*	+.002			

PLATE 40.—ZIRCONIUM.

Micrometer reading	Standard	Difference	Micrometer reading	Standard	Difference
3883.757	.773‡	—.016	4016.578	.578†	.000
3897.589	.599	—.010	4029.792	.796	—.004
3905.657	.666*	—.009	4034.638	.641†	—.003
3924.663	.669‡	—.006	4045.974	.975*	.001
3925.335	.345‡	—.010	4048.888	.893†	—.005
3926.123	.123†	.000	4055.700	.701‡	—.001
3937.470	.474†	—.004	4062.601	.602‡	—.001
3941.020	.021‡	—.001	4063.750	.756*	—.006
3942.556	.559†	—.003	4073.918	.920	—.002
3950.097	.101‡	—.004	4083.755	.767†	—.012
3950.485	.497	—.012	4083.925	.928	—.003
3954.001	.001	.000	4103.095	.101†	—.006
3957.180	.180*	.000	4107.642	.646†	—.004
3960.430	.429	+.001	4114.602	.600	—.002
3971.478	.478	.000	4121.476	.481	—.005
3977.895	.891	+.004	4121.907		
3981.916	.914‡	+.002	4157.936	.948	—.012
3984.080	.078†	+.002	4185.045	.063	—.018
3986.906	.903*	+.003	4197.238	.251‡	—.013
4016.572	.578	—.006			

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PLATE 44.—ZIRCONIUM.

Micrometer reading	Standard	Difference	Micrometer reading	Standard	Difference
4283.148	.170†	—.022	4415.289	.299†	—.010
4289.504	.523†	—.019	4425.607	.609†	—.002
4293.216	.249*	—.033	4447.889	.899	—.010
4222.339	.381	—.042	4454.936	.950†	—.014
4226.848	.892†	—.044	4494.725	.735†	.010†
4250.924	.956†	—.032	4497.026	.041†	—.015
4302.680	.689†	—.009	4499.063	.070†	—.007
4308.064	.034*	+.030	4501.438	.444‡	—.006
4343.382	.387†	—.005	4508.449	.456	—.007
4352.895	.903	—.008	4554.187	.213†	—.026
4359.770	.778†	—.008	4571.265	.277†	—.012
4369.930	.943	—.013	4572.142	.157†	—.015
4391.140	.149	—.009	4578.720	.731‡	—.011
4404.917	.927†	—.010	4588.369	.384	—.015
4407.838	.850†	—.012	4590.112	.129	—.017

PLATE 48.—ZIRCONIUM.

Micrometer reading	Standard	Difference	Micrometer reading	Standard	Difference
4611.455	.453*	+.002*	4805.263	.253†	+.010
4629.509	.515†	—.006†	4810.732	.723†	+.009
4637.683	.683	.000	4823.705	.697†	+.008
4638.189	.194‡	—.005	4824.334	.325	+.009
4668.300	.303*	—.003	4859.939	.934‡	+.005
4678.345	.353†	—.008	4883.876	.867†	+.009
4686.392	.395†	—.003	4893.045	.030†	+.015
4690.325	.324†	+.001	4917.410	.410†	.000
4691.574	.581*	—.007	4924.104	.109	—.005
4703.181	.180*	+.001*	4934.248	.247*	+.001
4722.355	.349‡	+.006	4936.005	.015†	—.010
4727.628	.628†	.000	4991.221	.247†	.026
4754.230	.226†	+.004	4994.292	.316	—.024

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THE ARC-SPECTRUM OF ZIRCONIUM.

Wave-length uncorrected	Correction	Intensity and Character	Wave-length corrected	Wave-length uncorrected	Correction	Intensity and Character	Wave-length corrected
3054.929	—.002	10	3054.927	3205.028	—.012	3	3205.016
3060.220	—.002	5	3060.218	3208.444	—.012	3	3208.432
3061.451	—.002	3	3061.449	3212.135	—.012	5	3212.123
3064.748	—.002	4	3064.746	3212.974	—.012	3	3212.962
3065.315	—.002	3	3065.313	3214.318	—.012	7	3214.306
3072.240	—.002	1 n	3072.238	3228.933	—.011	7	3228.922
3085.465	—.004	2	3085.461	3234.250	—.010	7	3234.240
3094 914	—.006	2	3094.908	3235.884	—.010	1	3235.874
3095.180	—.006	8	3095.174	3241.180	—.009	7	3241.171
3095.441	—.006	1	3095.435	3244.116	—.008	1	3244.108
3099.331	—.007	10	3099.324	3247.680	—.008	1	3247.672
3109.453	—.009	1 n	3109.444	3250.570	—.007	7	3250.563
3106.682	—.008	10	3106.674	3260.245	—.005	3	3260.240
3110.654	—.009	1	3110.645	3264.949	—.004	3	3264.945
3110.980	—.009	10	3110.971	3269.791	—.003	7	3269.788
3119.330	—.010	1	3119.320	3272.335	—.002	7	3272.333
3120.861	—.010	8	3120.851	3273.170	—.002	7	3273.168
3125.319	—.011	4	3125.308	3279.400	—.001	10	3279.399
3126.021	—.011	10	3126.010	3280.601	—.001	1 n	3280.600
3129.286	—.011	10	3129.275	3282.969	—.000	2	3282.969
3129.865	—.011	10	3129.854	3284.827	—.000	10	3284.827
3132.177	—.011	7	3132.166	3286 025	—.000	2	3286.025
3133.335	—.011	2	3133.324	3288.934	+.001	5	3288.935
3133.595	—.011	8	3133.584	3306.409	+.002	7	3306.411
3137.083	—.011	4	3137.072	3310.022	+.002	3	3310.024
3138.775	—.011	10	3138.764	3311.480	+.002	2	3311.482
3149.937	—.012	3	3149.925	3313.830	+.002	5	3313.832
3155.792	—.012	7	3155.780	3314.613	+.002	7	3314.615
3157.108	—.012	7	3157.096	3316.323	+.002	1	3316.325
3157.944	—.012	7	3157.932	3318.640	+.002	4	3318.642
3164.423	—.012	10	3164.411	3319.146	+.002	7	3319.148
3165.570	—.012	7	3165.558	3323.115	—.001	7	3323.114
3166.076	—.012	7	3166.064	3326.545	—.001	1	3326.544
3166.387	—.012	6	3166.375	3334.381	+.001	7	3334.382
3166.749	—.012	1	3166.837	3334.743	+.001	7	3334.744
3178.205	—.012	7	3178.193	3338.543	+.002	7	3338.545
3185.183	—.012	8	3185.171	3340.611	+.003	7	3340.614
3182.050	—.012	7	3182.038	3344.913	+.004	7	3344.917
3182.965	—.012	10	3182.953	3353.775	+.008	2	3353.783
3191.340	—.012	7	3191.328	3376.375	+.020	5	3376.395
3192.024	—.012	7	3192.012	3377.565	+.020	5	3377.585
3194.548	—.012	1	3194.536	3380.038	+.022	1	3380.060
3196.844	—.012	1	3196.832	3387.976	+.026	7	3388.002
3204.485	—.012	3	3204.473	3388.345	+.026	7	3388.371

ZIRCONIUM—*continued.*

Wave-length uncorrected	Correction	Intensity and Character	Wave-length corrected	Wave-length uncorrected	Correction	Intensity and Character	Wave-length corrected
3392.350	+.028	10	3392.378	3663.778	+.006	8	3663.784
3393.239	+.029	7	3393.268	3671.403	+.007	2	3671.410
3394.360	+.029	1	3394.389	3674.852	+.007	3	3674.859
3396.438	+.030	7	3396.468	3680.666	+.008	5	3680.674
3398.965	+.032	7	3398.997	3691.521	+.009	8	3691.530
3402.977	+.034	5	3403.011	3696.421	+.009	1 ?	3696.430
3403.806	+.034	1	3403.840	3697.593	+.010	2	3697.603
3404.955	+.033	5	3404.987†	3891.504	+.012	5	3891.516
3407.595	+.032	1 n	3407.627	3892.149	+.012	1, n	3892.161
3408.198	+.037	7	3408.235	3896.653	+.011	2	3896.664
3410.374	+.031	1	3410.405	3897.788	+.010	1	3897.798
3410.328	+.038	7	3410.366	3900.639	+.010	5	3900.649
3414.787	+.020	1	3414.816	3916.060	+.007	5	3916.067
3419.786	+.027	1	3419.813	3921.023	+.005	5	3921.928
3424.953	+.025	1	3424.978	3920.662	+.004	6	3929.666
3430.661	+.022	3	3430.683	3934.250	+.004	4	3934.254
3437.271	+.020	2	3437.291	3934.915	+.004	4	3934.919
3438.361	+.020	5	3438.381	3936.188	+.003	2	3936.191
3446.754	+.016	3	3446.770	3941.756	+.002	2	3941.758
3447.498	+.016	4	3447.514	3958.353	+.001	8	3958.354
3456.042	+.014	3	3456.056	3966.417	.000	1, n	3966.417
3457.327	+.013	2	3457.340	3973.549	.000	1	3973.549
3457.702	+.013	3	3457.715	3975.435	—.001	4	3975.434
3459.071	+.012	1	3459.083	3977.422	—.001	3	3977.421
3461.232	+.012	3	3461.244	3979.375	—.001	3	3979.374
3463.155	+.011	3	3463.166	3981.727	—.001	10	3981.726
3471.321	+.008	6	3471.329	3982.305	—.001	2	3982.304
3478.448	+.007	1	3478.455	3991.269	—.001	8	3991.268
3478.923	+.006	3	3478.929	4012.395	.000	4	4012.395
3481.295	+.005	5	3481.300	4018.520	.000	3	4018.520
3482.944	+.005	3	3482.949	4024.586	.000	3	4024.586
3483 674	+.005	3	3483.679	4025.060	.000	5	4025.060
3496.340	+.003	7	3496.343	4027.349	+.001	5	4027.350
3499.725	+.002	1	3499.727	4028.098	+.001	3	4028.099
3505.581	+.001	1	3505.582	4029.820	+.001	5	4029.821
3505.812	+.001	4	3505.813	4030.187	+.001	4	4030.188
3519.735	+.001	10	3519.736	4031.496	+.001	1	4031.497
3552.092	+.001	3	3552.093	4032.196	+.001	4	4032.197
3556.743	+.001	5	3556.744	4032.210	+.001	1	4032.211
3558.942	+.002	1	3558.944	4034.230	+.001	3	4034.231
3572.603	+.003	10	3572.606	4036.038	+.001	4	4036.039
3601.326	+.005	10	3601.331	4040.386	+.002	3	4040.388
3612.037	+.005	1	3612.042	4041.787	+.002	3	4041.789
3613.242	+.005	3	3613.247	4042.371	+.002	3	4042.373
3614.920	+.005	5	3614.925	4043.720	+.002	5	4043.722
3624.000	+.005	8	3624.005	4045.756	+.002	6	4045.758
3630.164	+.005	1	3630.169	4045.970	+.002	3	4045.972
3634.293	+.005	3	3634.298	4048.811	+.002	7	4048.813
3636.596	+.005	2	3636.601	4049.714	+.002	5	4049.716
3658.285	+.005	1, n	3658.290	4050.465	+.002	3	4050.467

ZIRCONIUM—*continued.*

Wave-length uncorrected	Correction	Intensity and Character	Wave-length corrected	Wave-length uncorrected	Correction	Intensity and Character	Wave-length corrected
4054.579	+.002	3	4054.581	4183.459	+.013	4	4183.472
4055.171	+.002	5	4055.173	4186.821	+.013	2	4186.834
4055.849	+.002	4	4055.851	4191.635	+.015	2	4191.650
4056.653	+.002	1	4056.655	4191.931	+.016	1	4191.947
4057.982	+.002	2	4057.984	4194.147	+.016	2	4194.163
4058.769	+.002	2	4058.771	4194.909	+.016	4	4194.925
4060.231	+.002	1	4060.233	4196.280	+.017	3	4196.297
4060.728	+.002	2	4060.730	4227.839	+.041	8	4227.880
4061.676	+.002	4	4061.678	4231.644	+.039	4	4231.683
4064.301	+.002	8	4064.303	4231.716	+.039	3	4231.755
4068.870	+.002	2	4068.872	4234.717	+.038	3	4234.755
4071.240	+.002	2	4071.242	4236.153	+.037	5	4236.190
4072 840	+.002	10	4072.842	4237.517	+.037	2	4237.554
4075.070	+.002	3	4075.072	4239.392	+.036	8	4239.428
4076.676	+.002	3	4076.678	4240.420	+.034	8	4240.454
4077.199	+.002	2	4077.201	4241.286	+.033	8	4241.319
4078.455	+.002	4	4078.457	4241.770	+.033	8	4241.803
4081.359	+.002	10	4081.361	4253.660	+.030	2	4253.690
4082.439	+.002	2	4082.441	4256.546	+.029	2	4256.575
4083.239	+.002	2	4083.241	4258.142	+.029	7	4258.171
4084.450	+.002	3	4084.452	4261.304	+.027	2	4261.331
4085.838	+.002	5	4085.840	4261.526	+.027	2	4261.553
4087.836	+.002	2	4087.838	4264.115	+.026	1, n	4264.141
4090.662	+.002	6	4090.664	4265.015	+.026	1	4265.041
4090.943	+.002	3	4090.945	4266.828	+.025	1	4266.853
4093.311	+.002	2	4093.313	4268.116	+.025	5	4268.141
4094.416	+.002	2	4094.418	4273.620	+.023	4	4273.643
4096.781	+.002	3	4096.783	4274.861	+.023	2	4274.884
4099.458	+.002	2	4099 460	4277.465	+.022	2	4277.487
4107.690	+.002	3	4107.692	4282.306	+.020	5	4282.326
4108.544	+.002	3	4108.546	4285.354	+.019	1, n	4285.373
4110.195	+.002	1	4110.197	4286.615	+.019	1, n	4286.634
4110.801	+.002	1	4110.803	4289.266	+.018	1, n	4289.284
4113.115	+.002	1	4113.117	4290.314	+.018	1, n	4290.332
4120.309	+.002	1	4120.311	4291.454	+.016	2	4291.470
4121.601	+.002	5	4121.603	4294.897	+.017	7	4294.914
4128.125	+.002	1	4128.127	4296.311	+.016	2	4296.327
4135.828	+.002	4	4135.830	4300.681	+.015	1, n	4300.696
4140.158	+.003	2	4140.161	4302.990	+.015	5	4303.005
4146.034	+.004	1 n	4146.038	4304.803	+.014	3	4305.817
4149.339	+.004	10	4149.443	4306.034	+.014	1	4306.048
4151.118	+.005	4	4151.123	4309.931	+.013	1	4309.944
4152.788	+.005	4	4152.793	4312.342	+.012	1	4312.354
4156.377	+.006	8	4156.383	4317.424	+.011	5	4317.435
4161.345	+.007	7	4161.352	4319.164	+.011	2	4319.175
4166.501	+.008	4	4166.509	4321.287	+.011	2	4321.298
4169.494	+.009	1	4169.503	4324.145	+.011	2	4324.156
4171.616	+.009	3	4171.625	4325.554	+.010	4	4325.564
4179.953	+.011	3	4179.964	4329.685	+.010	2	4329.695
4182.710	+.012	5	4182.722	4333.380	+.010	2	4333.390

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ZIRCONIUM—*continued.*

Wave-length uncorrected	Correction	Intensity and Character	Wave-length corrected	Wave-length uncorrected	Correction	Intensity and Character	Wave-length corrected
4336.463	+.010	1, N	4336.473	4490.392	+.010	1, N	4490.402
4337.741	+.010	1	4337.751	4494.550	+.010	3	4494.560
4341.248	+.019	7	4341.258	4495.588	+.010	1	4495.598
4342.356	+.010	1, n	4342.366	4497.139	+.010	7	4497.149
4343.160	+.010	1	4343.170	4507.250	+.010	4	4507.260
4343.517	+.010	1, n	4343.527	4526.265	+.010	1, n	4526.275
4346.641	+.010	2	4346.651	4535.877	+.010	5	4535.887
4347.349	+.010	1	4347.359	4542.351	+.010	4	4542.361
4347.469	+.010	1	4347.479	4550.260	+.011	2	4550.271
4348.009	+.010	8	4348.019	4553.142	+.011	1	4553.153
4358.870	+.010	1	4358.880	4554.100	+.011	1	4554.111
4359.852	+.010	8	4359.862	4554.174	+.011	2	4554.185
4360.427	+.010	4	4360.437	4555.659	+.011	2	4555.670
4366.571	+.010	4	4366.581	4558.175	+.011	1, n	4558.186
4371.078	+.010	7	4371.088	4565.587	+.012	1, n	4565.599
4373.203	+.010	1	4373.213	4574.633	+.013	1, n	4574.646
4379.899	+.010	7	4379.909	4582.435	+.014	1, n	4582.449
4389.746	+.010	1, n	4389.756	4590.675	+.016	1, n	4590.691
4395.066	+.010	3	4395.076	4614.092	+.004	1	4614.096
4400.365	+.010	1	4400.375	4629.223	+.004	1	4629.227
4401.481	+.010	1	4401.491	4634.139	+.004	1	4634.143
4403.472	+.010	1, n	4403.482	4640.290	+.004	1, n	4640.294
4414.439	+.010	2	4414.449	4644.982	+.004	1, n	4644.986
4414.665	+.010	3	4414.675	4657.795	+.004	1	4657.799
4420.588	+.010	3	4420.598	4661.958	+.004	1, n	4661.962
4427.373	+.010	2	4427.383	4667.314	+.004	1, n	4667.318
4429.235	+.010	1	4429.245	4683.592	+.004	1	4683.596
4431.619	+.010	3	4431.629	4687.971	+.004	3	4687.975
4435.976	+.010	1, n	4435.986	4688.621	+.004	1	4688.625
4436.900	+.010	1, n	4436.910	4707.952	+.002	1, n	4707.954
4454.929	+.010	5	4454.939	4710.250	+.002	3	4710.252
4455.564	+.010	1	4455.574	4712.085	+.002	1	4712.087
4456.428	+.010	1	4456.438	4717.795	.000	1, n	4717.795
4457.552	+.010	4	4457.562	4719.291	.000	1, n	4719.291
4460.485	+.010	4	4460.495	4732.510	—.003	1	4732.507
4460.920	+.010	1	4460.930	4739.655	—.004	1	4739.651
4467.044	+.010	1	4467.054	4762.955	—.008	1	4762.947
4468.354	+.010	1	4468.364	4772.498	—.009	2	4772.489
4469.654	+.010	1, n	4469.664	4785.103	—.009	1	4785.094
4470.451	+.010	2	4470.461	4788.862	—.009	1	4788.853
4470.688	+.010	4	4470.698	4806.060	—.009	1	4806.047†
4482.170	+.010	1	4482.180	4934.245	—.009	1	4934.236
4485.577	+.010	1, n	4485.587				

SOLAR LINES FOR STANDARDS.

PLATE 32.—LANTHANUM.

Micrometer reading	Standard	Difference	Micrometer reading	Standard	Difference
3094.998	95.003‡	—.005	3247.667	.680*	—.013
3106.659	.677*	—.018	3260.373	.384‡	—.011
3115.152	.160†	—.008	3267.832	.839	—.007
3129.875	.882‡	—.005	3274.070	.092†	—.022
3137.443	.441†	+.002	3287.771	.791‖	—.020
3140.875	.870†	+.005	3292.153	.174*	—.021
3153.872	.870†	+.002	3295.932	.957‖	—.025
3167.294	.290‡	+.004	3302.485	.501‡	—.016
3172.174	.175†	—.001	3303.624	.648*	—.024
3176.103	.104†	—.001	3306.446	.471†	—.025
3188.165	.164‡	+.001	3308.907	.928*	—.021
3200.031	.032†	—.001	3318.131	.163	—.032
3218.390	.390	.000	3331.719	.741‡	—.022
3224.370	.368†	+.002	3347.990	48.011*	—.021
3231.437	.421*	+.016	3356.190	.222	—.032
3232.403	.404‡	.001	3377.620	.667*	—.047
3646.123	.124	—.001	3389.847	.887	—.040

PLATE 36.—LANTHANUM.

Micrometer reading	Standard	Difference	Micrometer reading	Standard	Difference
3441.103	.135*	—.032	3570.416	.402*	+.014
3444.026	.032*	—.006	3581.340	.344	—.004
3455.353	.384	—.031	3583.476	.483	—.007
3464.585	.609	—.024	3600.880	.880*	.000
3477.987	78.001	—.014	3606.829	.831*	—.002
3486.022	.036‡	—.014	3612.210	.217‖	—.007
3491.448	.464	—.016	3617.918	.920*	—.002
3500.695	.721‡	—.026	3618.922	.924*	—.002
3500.985	.993‡	—.008	3622.149	.149*	.000
3510.981	.987‡	—.006	3623.330	.332	—.002
3513.941	.947†	—.006	3623.601	.603	—.002
3518.482	.487	—.005	3623.603	.603	.000
3521.402	.404*	—.002	3628.846	.853*	—.007
3540.260	.266	—.006	3628.858	.853*	+.005
3545.335	.333	+.002	3631.624	.619*	+.005
3549.995	50.006*	—.011	3638.430	.435*	—.005
3564.673	.680*	—.007	3647.995	.995†	.000
3565.530	.528*	+.002	3652.690	.692‡	—.002

PLATE 36 — LANTHANUM—*continued.*

Micrometer reading	Standard	Difference	Micrometer reading	Standard	Difference
3653.645	.639†	+.006	3749.620	.623*	—.003
3658.694	.688	+.006	3754.661	.664*	—.003
3667.397	.397	.000	3756.203	.211‡	—.008
3680.056	.064†	—.008	3758.364	.379*	—.015
3683.198	.202	—.004	3763.924	.442*	—.018
3687.595	.607*	—.012	3767.331	.344*	—.013
3695.188	.194	—.006	3770.116	.130*	—.014
3705.711	.711*	.000	3774.460	.480*	—.020
3707.185	.186	—.001	3780.826	.846‡	—.020
3710.429	.438*	—.009	3781.315	.330‡	—.015
3716.583	.585	—.002	3783.654	.674‡	—.020
3720.081	.086†	—.005	3788.016	.032*	—.016
3722.693	.691*	+.002	3793.995	94.014†	—.019
3727.758	.763*	—.005	3795.127	.150*	—.023
3735.020	.014*	+.006			

PLATE 40′ — LANTHANUM.

Micrometer reading	Standard	Difference	Micrometer reading	Standard	Difference
3883.767	.773‡	—.006	4003.910	.916‡	—.006
3886.420	.427†	—.007	4016.578	.578	.000
3897.593	.599‡	—.006	4029.781	.796	—.015
3905.662	.666†	—.004	4030.900	.914*	—.014
3916.872	.875‡	—.003	4033.213	.225*	—.012
3924.664	.669‡	—.005	4034.623	.641*	—.018
3926.120	.123†	—.003	4035.864	.880*	—.016
3928 070	.071*	—.001	4045.960	.975*	—.015
3937.476	.474‡	+.002	4048.880	.893*	—.013
3941.019	.021‡	—.002	4055.688	.701	—.013
3944.145	.159*	—.014	4062.589	.602	—.013
3954.001	.001‡	.000	4063.741	.756*	—.015
3957.170	.180*	—.010	4071.882	.904*	—.022
3961.667	.676*	—.009	4073.901	.920	.019
3971.465	.478‡	—.013	4077.860	.883*	.023
3973.830	.835*	—.005	4083.739	.767*	.028
3977.887	.891	—.004	4088.702	.716	—.014
3981.916	.914‡	+.002	4103.075	.101	—.026
3984.085	.078†	+.007	4107.626	.640*	—.014
3989.222	.216†	+.006	4114.578	.600	—.022

PLATE 40''—LANTHANUM.

Micrometer reading	Standard	Difference	Micrometer reading	Standard	Difference
3950.101	.101	.000	4063.749	.756*	—.007
3954.005	.001	+.004	4071.893	.904*	—.011
3957.182	.180†	+.002	4073.918	.920*	—.002
3960.430	.429	+.001	4107.639	.646†	—.007
3971.478	.478†	.000	4114.602	.600	+.002
3984.085	.078†	+.007	4121.475	.481‡	—.006
3987.226	.216*	+.010	4157.923	.948	—.025
4003.918	.916‡	+.002	4185.036	.063	—.027
4016.577	.578	—.001	4197.224	.251†	—.027
4029.786	.796	—.010	4077.874	.883*	.009
4030.900	.914†	—.014	4083.905	.928	—.023
4033.223	.225†	—.002	4088.710	.716	—.006
4034.632	.641†	—.009	4114.591	.600	—.009
4044.280	.293*	—.013	4157.918	.948	—.030
4045.980	.975*	+.005	4185.026	.063	—.037
4048.881	.893†	—.012	4197.222	.251†	—.029

PLATE 44.—LANTHANUM.

Micrometer reading	Standard	Difference	Micrometer reading	Standard	Difference
4222.347	.381	—.034	4435.140	.132†	+.008
4254.498	.502*	—.004	4435.865	.852‡	+.013
4260.630	.638*	—.008	4447.909	.899‡	+.010
4293.232	.249†	—.017	4454.953	.950*	+.003
4318.811	.818†	—.007	4494.742	.735‡	+.007
4352.907	.903	+.004	4508.461	.456	+.005
4369.956	.943†	+.013	4554.210	.213†	.003
4376.108	.103†	+.005	4571.273	.277‡	—.004
4407.850	.850†	.000	4578.733	.731	+.002
4425.624	.609‡	+.015			

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PLATE 44′.—LANTHANUM.

Micrometer reading	Standard	Difference	Micrometer reading	Standard	Difference
4250.258	.290*	—.032	4383.722	.721†	+.001
4250.945	.956†	—.011	4391.161	.149‡	+.012
4254.476	.502‡	—.026	4404.937	.927†	+.010
4260.623	.638*	—.015	4407.846	.850*	—.004
4267.928	.958*	—.030	4415.305	.299*	+.006
4271.914	.924†	—.010	4435.853	.852‡	+.001
4274.941	.958*	—.017	4435.133	.132*	+.001
4283.154	.170*	—.016	4447.912	.899‡	+.013
4289.510	.523*	—.013	4454.947	.950†	—.003
4289.872	.881*	—.009	4456.038	.047*	.009
4293.231	.249*	—.018	4494.736	.735	+.001
4299.135	.152*	—.017	4497.031	.041‡	—.010
4302.681	.689*	—.008	4499.075	.070*	+.005
4307.889	.904*	—.015	4499.308	.315*	—.007
4308.057	.071*	—.014	4501.449	.444	+.005
4318.804	.818	—.014	4508.459	.456	+.003
4325.925	.940†	—.015	4554.206	.213‡	—.007
4343.400	.387*	+.013	4563.941	.939	+.002
4352.904	.903	+.001	4571.269	.277	—.008
4359.784	.778*	+.006	4572.146	.157	—.011
4369.946	.943	+.003	4578.724	.731	—.007
4376.117	.103	+.014	4588.368	.384	—.016

PLATE 44″.—LANTHANUM.

Micrometer reading	Standard	Difference	Micrometer reading	Standard	Difference
4215.617	.616†	+.001	4307.890	.904†	—.014
4226.860	.892*	—.032	4308.060	.034†	+.026
4250.268	.290†	—.022	4318.804	.818‡	—.014
4254.477	.502*	—.025	4325.927	.940†	—.013
4260.625	.638†	—.013	4359.786	.778†	+.008
4267.923	.958‡	—.035	4369.930	.943‡	—.013
4271.910	.924*	—.014	4376.102	.103‡	—.001
4274.947	.958†	—.011	4383.720	.721*	—.001
4283.555	.523*	+.032	4407.844	.850†	—.006
4283.142	.170*	—.038	4415.290	.299†	—.009
4289.511	.523*	—.012	4425.607	.609†	—.002
4293.231	.249†	—.018	4435.128	.132†	—.004
4299.144	.152*	—.008	4435.856	.852‡	+.004
4302.683	.689*	—.006	4447.894	.899‡	—.005
4306.057	.071†	—.014	4454.958	.950*	+.008

PLATE 44‴.—LANTHANUM.

Micrometer reading	Standard	Difference	Micrometer reading	Standard	Difference
4293.238	.249‡	—.011	4407.850	.850‡	.000
4318.814	.818†	—.004	4435.140	.132‡	+.008
4352.914	.903	+.011	4447.918	.899‡	+.019
4369.960	.943‡	+.017	4454.958	.950†	+.008
4376.115	.103‡	+.012	4494.750	.735‡	+.015
4425.623	.609‡	+.014	4508.468	.456‡	+.012
4435.871	.852‡	+.019	4554.218	.213†	+.005
4447.920	.899‡	+.021	4571.276	.277†	—.001

PLATE 48.—LANTHANUM.

Micrometer reading	Standard	Difference	Micrometer reading	Standard	Difference
4629.505	.515‡	—.010	4824.335	.325‡	+.010
4637.669	.683	—.014	4810.723	.723*	.000
4643.631	.645	—.014	4903.483	.488†	—.005
4686.389	.395	—.006	4919.175	.183†	—.008
4703.999	.986	+.013	4924.955	.955	.000
4703.182	.180†	+.002	4934.244	.247†	—.003
4722.348	.349†	—.001	4973.262	.274	—.012
4727.638	.628‡	+.010	4978.760	.782†	—.022
4754.237	.226†	+.011	4994.301	.316	—.015
4859.930	.934‡	—.004			

PLATE 48′.—LANTHANUM.

Micrometer reading	Standard	Difference	Micrometer reading	Standard	Difference
4602.152	.183	—.031	4783.607	.601*	+.006
4607.470	.509‡	—.039	4805.260	.253†	+.007
4611.423	.453‡	—.030	4810.734	.723*	+.011
4629.501	.515‡	—.014	4823.690	.697†	—.007
4637.672	.683	—.011	4824.337	.325‡	+.012
4643.625	.645	—.020	4859.936	.934	+.002
4648.821	.835†	—.014	4890.923	.945†	—.022
4668.289	.303†	—.014	4805.253	.253†	.000
4678.345	.353†	—.008	4810.728	.723*	+.005
4683.738	.743	—.005	4783.614	.601†	+.013
4686.398	.395	+.003	4754.222	.226‡	—.004
4690.312	.324	—.012	4727.620	.628‡	—.008
4691.567	.581†	—.014	4722.340	.349†	—.009
4691.570	.581†	—.011	4810.732	.723*	+.009
4703.186	.180†	+.006	4823.687	.697‡	—.010
4714.600	.599*	+.001	4824.329	.325‡	+.004
4722.341	.349‡	—.008	4859.938	.934‡	+.004
4727.634	.628†	+.006	4859.933	.934‡	—.001
4754.232	.226†	+.006	4900.091	.098‡	—.007

PLATE 52.—LANTHANUM.

Micrometer reading	Standard	Difference	Micrometer reading	Standard	Difference
5005.851	.904‡	—.053	5225.691	.690	+.001
5006.251	.303‡	—.052	5230.020	.014‡	+.006
5014.379	.422*	—.043	5233.111	.124‡	+.013
5020.173	.210‡	—.037	5242.662	.662‡	.000
5049.972	50.008	—.036	5250.374	.391‡	—.017
5060.226	.252‡	—.026	5253.630	.649	—.019
5064.810	.833‡	—.023	5261.868	.880‡	—.012
5068.921	.946	—.025	5266.714	.729‡	—.015
5083.501	.525‡	—.024	5269.716	.722*	—.006
5090.933	.959‡	—.026	5273.548	.554*	—.006
5109.807	.825‡	—.018	5281.950	.968‡	—.018
5115.554	.558‡	—.004	5283.789	.803‡	—.014
5127.520	.530‡	—.010	5288.688	.708‡	—.020
5146.651	.664‡	—.013	5296.858	.873‡	—.015
5155.931	.937‡	—.006	5300.902	.918‡	—.016
5165.575	.588‡	—.013	5307.519	.546‡	—.027
5171.779	.783‡	—.004	5324.345	.373‡	—.028
5183.786	.792†	—.006	5333.060	.092‡	—.032
5189.020	.020†	.000	5349.617	.623†	—.006
5188.843	.863*	—.020	5361.775	.813†	—.038
5193.141	.139‡	+.002	5367.617	.670‡	—.053
5198.875	.885‡	—.010	5370.120	.165‡	—.045
5202.475	.483†	—.008	5379.724	.776‡	—.052
5204.700	.708†	—.008	5383.518	.576‡	—.058
5215.344	.352‡	—.008	5393.318	.378‡	—.060
5217.561	.559‡	+.002	5397.284	.346‡	—.062

PLATE 56.—LANTHANUM.

Micrometer reading	Standard	Difference	Micrometer reading	Standard	Difference
5455.829	.826*	+.003	5590.345	.342†	+.003
5463.491	.493	—.002	5594.685	.695†	—.010
5466.601	.608	—.007	5598.519	.555*	—.036
5477.126	.128	—.002	5598.702	.715*	—.013
5487.959	.968	—.009	5601.501	.501‡	.000
5497.730	.731	—.001	5603.096	.097*	—.001
5501.683	.685	—.002	5615.525	.526	—.001
5513.204	.207	—.003	5615.882	.879‡	+.003
5528.631	.636†	—.005	5624.245	.253	—.008
5535.059	.073	—.014	5624.776	.768	+.008
5544.160	.158	+ 002	5634.171	.167	+.004
5555.109	.113	—.004	5641.663	.661	+.002
5569.844	.848‡	—.004	5645.831	.835	—.004
5576.317	.319	—.002	5655.714	.707	+.007
5588.975	.98$_0$†	—.005	5658.073	.096*	—.023

PLATE 56.—LANTHANUM—*continued.*

Micrometer reading	Standard	Difference	Micrometer reading	Standard	Difference
5662.744	.745‖	—.001	5742.059	.066‖	—.007
5675.648	.648‖	.000	5752.246	.257‖	—.011
5679.245	.249	—.004	5754.869	.884‡	—.015
5682.859	.861‖	—.002	5763.205	.215†	—.010
5688.431	.434‡	—.003	5772.358	.360‡	—.002
5701.772	.769‡	+.003	5782.342	.346†	—.004
5708.614	.620†	—.006	5784.066	.081‖	—.015
5711.304	.318*	—.014	5788.123	.136‡	—.013
5715.300	.309‡	—.009	5791.192	.207*	—.015
5731.980	.973‡	+.007	5798.056	.087‖	—.031

PLATE 54.—LANTHANUM.

Micrometer reading	Standard	Difference	Micrometer reading	Standard	Difference
5784.074	.081‖	—.007	5884.062	.048*	+.014
5788.130	.136‖	—.006	5905.895	.895‡	.000
5798.071	.087‖	—.016	5914.379	.384†	—.005
5798.391	.400‡	—.009	5916.480	.475‡	+.005
5806.950	.954‡	—.004	5919.853	.855‡	—.002
5809.438	.437‡	+.001	5930.405	.410‡	—.005
5816.590	.594†	—.004	5934.885	.883‡	+.002
5831.820	.832‖	—.012	5948.761	.761‡	.000
5853.898	.903‖	—.005	5956.923	.925‡	—.002
5857.666	.672†	—.006	5975.570	.576	—.006
5862.585	.580†	+.005			

THE ARC-SPECTRUM OF LANTHANUM.

Wave-length uncorrected	Correction	Intensity and Character	Wave-length corrected	Wave-length uncorrected	Correction	Intensity and Character	Wave-length corrected
3104.694	+.008	1	3104.702	4031.846		7	4031.847†
3142.882	—.001	2	3142.881	4035.328	.000	1, n	4035.328
3176.105	—.002	2	3176.103	4035.878	.000	1, n	4035.878
3215.936	—.001	2	3215.935	4036.976		1, n	4036.974†
3236.670	+.001	1	3236.671	4043.071		8	4043.070†
3245.247	+.003	5	3245.250	4045.961	+.001	10	4045.962
3249.477	+.004	4	3249.481	4050.215		6	4050.217†
3265.786	+.009	5	3265.795	4059.631	+.002	1, n	4059.633
3303.219	+.022	5	3303.241	4060.460		4	4060.459†
3337.597	+.033	6	3337.630	4062.886	+.002	1, n	4062.888
3344.671	+.034	5	3344.705	4063.732	+.003	1	4063.735
3376.436	+.036	3	3376.472	4064.922		3	4064.922†
3381.010	+.036	8	3381.046	4065.713		3	4065.715†
3452.296	+.034	3	3452.330	4067.520		5	4067.519†
3453.279	+.033	3	3453.312	4076.841	+.004	2	4076.845
3461.300	+.027	3	3461.327	4077.499	+.004	10	4077.503
3510.116	+.005	3	3510.121	4077.852	+.004	1	4077.856
3513.045	+.005	3	3513.050	4078.886	+.004	1	4078.890
3514.187	+.004	4	3514.191	4086.843	+.005	10	4086.848
3574.560	+.005	5	3574.565	4089.746	+.006	1	4089.752
3641.677	—.002	5	3641.675	4090.541	+.006	1	4090.547
3645.549	—.002	5	3645.547	4090.161	+.006	1	4090.167
3649.664	—.003	5	3649.661	4090.914	+.006	6	4090.920
3650.316	—.003	5	3650.313	4095.271	+.007	3	4095.278
3672.150	—.003	3	3672.147	4099.671		8	4099.678†
3680.050	—.002	1	3680.048	4105.018		10	4105.026†
3734.995	+.006	3	3735.001	4123.382	+.012	3	4123.394
3759.205	+.012	7	3759.217	4181.856		10	4141.872†
3790.935	+.018	6	3790.953	4144.075	+.017	2	4144.092
3794.886	+.018	7	3793.904	4152.098	+.021	8	4152.119
3883.948	+.007	2	3883.955	4152.100	+.020	2	4154.120
3886.489		7	3886.495†	4192.465	+.036	8	4192.501
3916.050	+.003	4	3916.053	4194.332	+.037	1	4194.360
3936.351	.000	7	3936.351	4194.617		1	4194.654†
3949.256	.000	6	3949.256	4204.155	+.063	5	4204.218
3988.669	.000	5	3988.669	4215.637	+.046	2	4215.683
3995.903	.000	5	3995.903	4217.690	+.043	6	4217.733
4013.400	—.001	1	4013.399	4226.862	+.036	6	4226.898
4013.535	.000	1	4013.535	4231.074	+.033	4	4231.107
4015.535		2	4015.531†	4238.512		10	4238.543†
4023.720		3	4023.717†	4250.126		5	4250.144†
4023.999	.000	4	4023.999	4254.478	+.026	1	4254.504
4025.786	.000	3	4025.786	4263.734		7	4263.742†
4026.014		7	4026.013†	7275.782		4	4275.797†

† Mean of several values obtained from different plates.

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LANTHANUM—*continued.*

Wave-length uncorrected	Correction	Intensity and Character	Wave-length corrected	Wave-length uncorrected	Correction	Intensity and Character	Wave-length corrected
4280.411		3	4280.418†	4692.678	+.002	6	4692.680
4282.537		2	4282.560†	4699.810	+.001	1, n	4699.811
4283.165	+.015	1	4283.180	4703.458	+.001	1	4703.459
4287.111		10	4287.128†	4703.429	.000	1	4703.429
4296.196		10	4296.210†	4716.624	—.001	3	4716.623
4300.765		2	4300.782†	4716.705	—.001	1, n	4716.704
4302.683		1	4302.699†	4728.598		5	4728.594†
4316.060		8	4316.076†	4743.277		7	4743.273†
4318.813	+.012	1	4318.825	4748.915		4	4748.911†
4333.924		15	4333.934†	4767.078	—.005	2	4767.073
4335.126		7	4335.134†	4796.868		1, n	4796.862†
4354.565		8	4354.565†	4804.221		4	4804.219†
4363.223		3	4363.221†	4809.188		5	4809.183†
4378.282		8	4378.274†	4809.695	—.005	5	4809.690
4383.628		7	4383.624†	4824.243		5	4824.239†
4385.360		4	4385.364†	4839.703		2	4839.697†
4411.380		2	4411.379†	4840.207		3	4840.203†
4419.332		3	4419.329†	4850.775		1, n	4850.772†
4423.350		1, n	4423.354†	4851.000	—.000	1, n	4851.000
4424.083		4	4424.082†	4861.082		4	4861.081†
4425.595	+.003	1, n	4425.598	4900.099	—.003	6	4900.096
4427.736		8	4427.741†	4921.148	+.001	6	4921.149
4430.079		10	4430.075†	4921.978	+.001	6	4921.979
4432.295	+.001	1, n	4432.296	4935.000	+.003	3	4935.003
4435.141		1	4435.139†	4949.941	+.006	3	4949.947
4435.389	+.003	1, n	4435.392	4952.232	+.006	1	4952.238
4452.331		5	4452.327†	4970.556	+.010	5	4970.566
4455.968		5	4455.965†	4987.044	+.015	6	4987.059
4499.223		2	4499.223†	4991.436	+.016	3	4991.452
4522.540		10	4522.544†	4999.625	+.017	0	4999.642
4525.468	—.002	7	4525.466	5001.929	+.050	11, n	5001.979
4526.279	+.014	8	4526.293	5002.255	+.050	1, n	5002.305
4549.677		7	4549.679†	5047.019	+.032	1, n	5047.051
4550.338		1	4550.337†	5050.704	+.030	1	5050.734
4550.952		2	4550.956†	5056.600	+.028	1	5056.628
4558.653		7	4558.660†	5063.071	+.026	1, n	5063.097
4568.085		5	4568.094†	5106.380	+.015	1	5106.395
4570.202		5	4570.215†	5114.709	+.014	4	5114.723
4575.048		8	4575.059†	5123.137	+.012	4	5123.149
4580.234		5	4580.245†	5145.573	+.009	1	5145.582
4605.922	+.029	4	4605.951	5156.881	+.007	1	5156.888
4613.532	+.025	5	4613.557	5157.575	+.007	1	5157.582
4620.022		3	4620.054†	5158.839	+.007	1	5185.846
4655.650		8	4655.667†	5163.762	+.006	1	5163.768
4662.661		5	4662.678†	5177.448	+.005	3	5177.453
4663.936	+.007	5	4663.943	5183.559	+.005	0, d	5183.664
4669.076		5	4669.080†	5188.366	+.005	11	5188.371
4671.985		4	4671.994†	5204.289	+.004	1	5204.293
4688.820		1, n	4688.824†	5212.010	+.004	1, n	5212.014
4691.340		4	4691.364†	5234.430	+.005	2	5234.435

LANTHANUM—*continued.*

Wave-length uncorrected	Correction	Intensity and Character	Wave-length corrected	Wave-length uncorrected	Correction	Intensity and Character	Wave-length corrected
5259.531	+.008	2	5259.539	5565.928	+.003	3	5565.931
5271.327	+.010	2	5271.337	5568.671	+.003	5	5568.674
5290.973	+.015	3	5290.988	5588.555	+.003	3	5588.558
5302.116	+.019	3	5302.135	5657.939	+.001	1	5657.940
5302.774	+.019	2	5302.793	5671.765	.000	2	5671.765
5303.686	+.022	3	5303.708	5703.530	.000	1	5703.530
5340.803	+.033	1	5340.836	5720.221	+.002	2, n	5720.223
5358.003	+.041	1, n	5358.044	5735.155	+.004	2, n	5735.159
5377.213	+.052	2	5377.265	5740.866	+.005	4	5740.871
5381.114	+.054	2	5381.168	5744.619	+.006	4	5744.625
5381.911	+.055	1, n	5381.966	5762.034	+.010	4	5762.044
5382.051	+.055	2	5382.106	5769.273	+.012	5	5769.285
5455.348	+.003	8	5455.351	5769.533	+.012	5	5769.545
5458.884	+.003	1	5458.887	5789.427	+.011	6	5789.438
5464.571	+.003	2	5464.574	5791.528	+.011	4	5791.539
5475.448	+.002	1, n	5475.450	5797.776	+.009	4	5795.785
5480.938	+.002	1, n	5480.940	5805.976	+.008	2	5805.984
5482.472	+.002	2	5482.474	5808.517	+.007	2	5808.524
5491.275	+.002	1	5491.277	5822.180	+.005	1	5822.185
5493.654	+.002	2	5493.656	5824.032	+.005	1	5824.037
5501.557	+.002	8	5501.559	5829.926	+.003	1, n	5829.929
5502.463	+.002	2	5502.465	5845.242	+.001	1, n	5845.243
5502.876	+.002	2	5502.878	5848.583	+.001	1, n	5848.584
5504.019	+.002	4	5504.021	5855.792	.000	1	5855.792
5515.500	+.002	1	5515.502	5863.903	+.001	2	5863.902
5517.560	+.002	2	5517.562	5874.202	+.002	1, n	5874.200
5535.886	+.003	3	5535.889	5874.943	+.002	1, n	5874.941
5545.129	+.003	2	5545.132	5930.330	.000	1	5830.330
5565.657	+.003	5	5565.660				

BIOGRAPHICAL SKETCH.

The author was born in Milwaukee, Wis., [illegible] 1864. He attended the public and high schools of his native city and entered the Department of Engineering, University of Wisconsin, from which he graduated in 1882. For several years he follwed the profession of Civil Engineering and served with several corporations. He was appointed Special Superintendent of Public Schools, Milwaukee, after a competitive examination. The author undertook graduate work in Physics, Astronomy and Mathematics in January, 1893, at the Johns Hopkins University.